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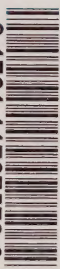
Office de Recherche et  
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de l'Énergie

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- 80152

# AN INVENTORY OF ENERGY RESEARCH AND DEVELOPMENT SUPPORTED BY THE GOVERNMENT OF CANADA

## 1978-80

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Report ER 80-6E

October 1, 1980

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GOVERNMENT OF CANADA 1978-80

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1978-80



October 7, 1980

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## FOREWORD

This Inventory lists the energy research and development activities funded by the Government of Canada for fiscal years 1978-79 and 1979-80, (1 April, 1978 to 31 March, 1980). It provides summary information to scientists and others interested in federal energy R&D programs. This information comes from reports received by the Interdepartmental Panel on Energy R&D which coordinates and monitors federal energy research.

The Panel is chaired by the Assistant Deputy Minister, Science and Technology, of the Department of Energy, Mines and Resources. Departments and agencies, represented on the Panel, that conduct energy research are:

- Agriculture Canada
- Atomic Energy Control Board
- Atomic Energy of Canada Limited
- Canada Mortgage and Housing Corporation
- Consumer and Corporate Affairs
- Energy, Mines and Resources
- Environment Canada
- Industry, Trade and Commerce
- National Research Council
- Transport Canada

The federal energy R&D activities are coordinated through the Office of Energy Research and Development in the Department of Energy, Mines and Resources. This office collects and analyzes information on R&D expenditures and person-year allocations in all departments and maintains an inventory of federally-sponsored energy R&D programs. R&D activities, classified into six Tasks, are reviewed in subcommittees chaired by Coordinators from agencies and departments responsible for specific Programs. These Task Coordinators report to the Panel on Energy R&D which, in turn, reports to the Minister of Energy, Mines and Resources.

The six Tasks are:

Task 1	Conservation
Task 2	Fossil Fuels
Task 3	Nuclear Energy
Task 4	Renewable Energy
Task 5	Energy Transportation and Transmission
Task 6	Overall Coordination

Each Task is divided into Programs and Subprograms. Thus, for example, the District Heating Subprogram is a part of the Thermal Wastes Program which, in turn, is a part of the Conservation Task. The Inventory is assembled at the Subprogram level. The Subprograms generally consist of several projects although not all such projects are identified.

This report contains three sections. An Introduction outlines the objectives of federal energy R&D and refers to work done by others in Canada and abroad. Next, is the Inventory itself which consists of a description of each Subprogram in the total federal effort in 1978-80. Finally, there are Appendices which contain a Glossary of Terms and other background information.

The collection and publication of information on all federal energy R&D activities is a responsibility of the Office of Energy Research and Development of Energy, Mines and Resources:

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Le présent rapport énumère les activités de recherche et développement (R&D) en énergie financées par le gouvernement du Canada pour les années financières 1978-79 et 1979-80 (du 1er avril 1978 au 31 mars 1980). Cette documentation est destinée aux scientifiques et à ceux qui s'intéressent aux programmes de R&D en énergie. Le renseignement ci-inclus sont extraits de rapports qui ont été présentés au Comité interministériel de la recherche et du développement énergétiques qui coordonne et contrôle la recherche énergétique du gouvernement fédéral.

Le comité est présidé par le sous-ministre adjoint, Sciences et Technologie, du Ministère de l'Énergie, des Mines et Ressources. Les ministères et organismes qui sont représentés au comité et qui s'occupent également de recherches énergétique sont:

- Agriculture Canada
- Commission de Contrôle de l'Énergie Atomique
- Conseil National de Recherches
- Consommation et Corporations Canada
- L'Énergie Atomique du Canada Limitée
- Énergie, Mines et Ressources
- Environnement Canada
- Industrie et Commerce
- Société Canadienne d'Hypothèques et de Logement
- Transports Canada

Les activités fédérales en matière de R&D énergétiques sont coordonnées par l'Office de recherche et développement énergétiques qui relève du ministère de l'Énergie, des Mines et des Ressources. L'Office rassemble et analyse les données relatives aux dépenses et à l'attribution d'années-personnes et tient un répertoire des programmes de R&D énergétiques financés par le gouvernement fédéral. Les activités, réparties en six missions, sont revues en sous-comités présidés par les coordonateurs des organismes et ministères qui ont la responsabilité de programmes précis. Les coordonateurs doivent faire rapport au comité de la recherche et du développement qui pour sa part, doit rendre compte au ministre de l'Énergie, des Mines et des Ressources. Les six missions sont les suivantes:

Mission 1	Économies d'énergie
Mission 2	Combustibles fossiles
Mission 3	Énergie nucléaire
Mission 4	Énergies renouvelables
Mission 5	Transport et transmission d'énergie
Mission 6	Coordination générale

Chaque mission est divisée en programmes et sous-programmes. Ainsi, le sous-programme Chauffage par ilot fait partie du programme Chaleur résiduaire qui, à son tour, relève de la mission Économies d'énergie. Ce rapport est établi au niveau des sous-programmes, qui comprennent généralement plusieurs projets qui ne sont pas tous énumérés ici.

Le rapport comprend trois sections. L'Introduction résume les objectifs que s'est fixé le gouvernement fédéral en matière de R&D énergétiques et renvoie aux travaux entrepris au Canada et à l'étranger. Ensuite le répertoire



décrit chaque sous-programme exécuté dans le cadre des efforts entrepris par le gouvernement fédéral de 1978 à 1980. Enfin, les annexes définissent les termes utilisés et fournissent d'autres données de base.

La collecte et la publication des données sur toutes les activités fédérales en matière de R&D énergétiques relèvent de l'Office de recherche et de développement énergétiques du ministère de l'Énergie, des Mines et des Ressources.

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## INTRODUCTION

## Purpose

The Canadian federal government regards the development of energy technology as essential to meeting Canada's energy future. Consequently, the government devotes considerable resources to energy R&D. These resources go not only to federal laboratories but also to provincial agencies, Canadian industry and universities, often in joint projects.

The purpose of this document is to describe the R&D supported by these resources. Specifically, this document is designed to inform those who are interested or engaged in energy R&D and related fields.

## Definition of Energy R&D

The definition of energy R&D is necessarily arbitrary. In this publication, the definition is taken to be R&D on energy production and utilization with the following exceptions generally applied:

- fundamental research funded by the federal granting councils
- socio-economic studies
- health and safety studies
- federal-provincial joint projects
- large-scale participation in new technologies at the demonstration or early commercial level (e.g. the Syncrude project)
- resource assessments

With respect to the environment, the energy R&D definition:

includes R&D on technologies which measure and minimize the amount of polluting emissions that result from energy activities. Examples are the reduction of stack emissions from thermal generating stations and improvements to pipelines or vessels so that they will not leak or spill energy commodities,

but excludes R&D on technologies which measure the environmental effects caused by emissions from energy activities and help the recovery of the environment. Examples are studies of the effects of stack emissions on human health and studies of the damage caused by oil spills.

## Objectives of Federal Energy R & D

The rationale for any particular research performed or funded by the federal government is based on one or more of the following criteria:

- the risk is very high or extended over a protracted period, so that the expected return is well below the norm for the private sector, e.g., advanced solar technologies;
- Canadian industry is currently too weak or fragmented to support significant R&D programs, e.g. coals;

- the return to society is greater than the return to an industry or industrial firm. In some cases leadership or example may be needed to stimulate changes from current practice, e.g., the development of the solar heating industry;
- in the national or regional interest, the development of an energy resource is beyond the capability of one or more provinces;
- the federal government must maintain a high level of expertise as backup to policy and regulatory decisions, e.g., specifications for the technology of transportation of fuels;
- the need for at least a minimum level of commitment in order to maintain some access to developments in other countries, e.g., nuclear fusion.

### Extramural Energy R&D

It is the policy of the federal government to promote the contracting out of federal research where feasible to the private sector. Federal energy R&D follows this policy and most of the increased funding in recent years has gone to extramural contracts. Examples of areas where this has been done are in efficient farm mechanization, coal gasification, and solar heating system trials.

### Provincial Activities

The provincial governments' concern for the energy problem is evident in the R&D activities they support. While these reflect regional concerns, much of the work is transferable and indeed there is much cooperation among the provincial research authorities and their federal counterparts.

A survey has been conducted by the Office of Energy Research and Development with the results published in the document "Estimated Energy R&D Funding by Provincial Governments in 1976-7 , 1977-8 and 1978-79," EMR Report No. ER 79-5. In 1978-79, the latest year for which figures are available, the provincial expenditures amounted to \$100 million.

### Federal-Provincial Agreements

The federal government has signed agreements with several provinces to jointly fund demonstrations of energy conservation and renewable energy technologies. The objectives of this work are to develop and demonstrate promising new technologies and to develop public awareness of their potential. A joint federal-provincial committee oversees each agreement. Detailed management of the work is a provincial responsibility. The total federal contribution, over several years, is expected to be about \$113 million. Approved projects as of September 1980 are listed in Appendix V.



## Canadian Industry

The private sector in Canada conducts a variety of energy research and development projects. An annual survey, conducted by Statistics Canada, on energy R&D expenditures by Canadian industry, indicated a 1979 expenditure of \$202 million, an increase of \$39 million over 1978.

The breakdown for 1979 was:

	\$ million
Conservation	23
Fossil fuels	102
Renewable Energy	5
Energy Transportation and Transmission	25
Other	47
Total	202

As might be expected, this R&D tends to be concentrated in the fossil fuels, traditionally the area of greatest activity in the Canadian private sector.

## Canadian Universities

The Strategic Grants program of the Natural Sciences and Engineering Research Council and the Research Agreements program of EMR are the major federal instruments for funding University research oriented specifically to energy problems. They are essential instruments for training manpower and expanding the universities' interest in applied problems. The total support by the federal government is in the order of \$4 million annually.

## International Energy Agency

The International Energy Agency, an autonomous body representing 21 countries within the Organization for Economic Cooperation and Development, was established in 1974 with present membership from west European nations together with New Zealand, Australia, Japan, the United States and Canada. The aims of the IEA include cooperation on energy R&D.

Canada's participation in the energy research, development and demonstration (RD&D) work of the IEA is significant and includes cooperation in the IEA's three principal activities:

- the development of a strategy for energy RD&D;
- the fostering of effective national programs of energy RD&D (including collaborative planning where feasible) through a process of national program reviews;
- the establishment and conduct of co-operative energy research, development and demonstration projects in priority areas.

The principal organizational mechanism for the IEA RD&D program is the Committee on Energy Research and Development which includes representatives from each IEA member country.

To carry out its work, the Committee established Working Parties (with specialists drawn from IEA countries) in the following fields: coal, solar energy, nuclear safety, radioactive waste management, fusion, hydrogen, wind, geothermal, ocean energy, biomass, conservation technology, high temperature gas-cooled reactors and enhanced recovery of petroleum. Joint participation in R&D proposed by these Working Parties is established through Implementing Agreements, many of which have been signed by Canada. For a list of these Agreements, see Appendix IV.

An overall RD&D strategy group was also established whose purpose is mainly the setting of priorities for energy RD&D activities appropriate to the participants. This work is carried out by two sub-groups, one located at Brookhaven National Laboratory (which is also the site of the main U.S. national effort in this field) and the other at a nuclear research station in Juelich, Germany. Canada participates in the international group's work at Brookhaven.

#### Federal Resources Applied to Energy R&D

The energy R&D funds spent annually by the federal government have been growing since the OPEC price increases began in 1973.

As TABLE 1 shows, the Renewable Resources Task was the recipient of most of the new funds awarded in 1979-80. The R&D being done with these new funds is in support of solar industry stimulation programs, e.g. PUSH and PASEM, and in support of biomass energy R&D through the ENFOR program. Funding for the other tasks remained largely unchanged.

The large variations in Overall Coordination reflect certain discretionary funds initially assigned to that Task but which eventually are applied to specific projects among the other five Tasks.

Because of internal variations in reporting resources, there may not be an exact correlation between the numbers on TABLE 1 and the funding numbers appearing on the subprogram sheets. The latter numbers are not presented, however, with accounting accuracy but rather are intended to reflect the magnitude of the research effort in each case.

TABLE 1 - ESTIMATES OF FEDERAL FUNDING OF ENERGY R&D

Task Program	1978-79 \$'000	1979-80 \$'000
1. <u>Conservation</u>		
1.1 Buildings	2,460	2,773
1.2 Transportation	2,401	2,586
1.3 Food Supply System	311	457
1.4 Thermal Wastes	1,041	938
1.5 Municipal and Industrial Wastes	1,751	1,060
1.6 Oil and Gas Combustion	574	579
1.7 Industrial Processes	1,500	1,500
1.8 Energy Conversion, Storage and Hydrogen Systems	2,040	2,154
1.9 Urban Form and Operations	150	150
1.10 Consumer Products and Lifestyles	254	265
TOTALS	12,482	12,462
2. <u>Fossil Fuels</u>		
2.0 Conventional Oil and Gas	211	222
2.1 Oil Sands and Heavy Oils	3,203	3,182
2.2 Coal Gasification and Liquefaction	1,740	2,174
2.3 Coal Supply	4,411	4,863
2.4 Coal Combustion	1,818	2,172
TOTALS	11,383	12,613
3. <u>Nuclear Energy</u>		
3.1 Regulatory Support	1,015	1,000
3.2 Fuel Resource Base	5,335	3,691
3.3 Utilization and Support	96,817*	98,816*
3.4 Fusion	2,640	2,866
TOTALS	105,807	106,373
4. <u>Renewable Resources</u>		
4.1 Hydraulic	621	500
4.2 Solar	7,866	10,171
4.3 Biomass	2,891	5,979
4.4 Wind	2,032	1,772
4.5 Geothermal	1,042	829
TOTALS	14,452	19,351
5. <u>Energy Transportation and Transmission</u>		
5.1 Energy Commodities	3,342	3,302
5.2 Transmission and Distribution of Electricity	2,763	2,996
TOTALS	6,105	6,298
6. <u>Overall Coordination</u>	456	798
GRAND TOTALS	150,685	157,895

\* Includes the maintenance and operation of large laboratory facilities.



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TASK 1  
CONSERVATION

## INTRODUCTION TO TASK 1: ENERGY CONSERVATION

The objectives of this task are to provide the basis for efficient patterns of energy end use and to develop technologies where eventual payoff is potentially high but which entails too much risk for prudent private sector investors or provincial governments to attempt on their own. As the basic science and technology of processes for converting source energy into useful forms are relatively well established, the technical effort pursued under this Task is on the reliability, practicality and economics of the application of the numerous energy conversion processes used in modern society.

### The Task Coordinator is:

Dr. T. Ledwell  
Conservation and Renewable Energy Branch  
Energy, Mines and Resources  
580 Booth Street  
Ottawa, Ontario  
K1A 0E4  
  
613-995-1801

The Conservation Task is divided into ten Programs:

#### 1.1 Buildings

The Program has concentrated on the development of energy conservation model codes for residences (1.1.1, 1.1.4), researching problems that have to be solved to develop performance type codes for non-residential buildings (1.1.2, 1.1.3, 1.1.5) testing insulation and developing insulation standards (1.1.6), air replacement studies (1.1.7). Review studies are underway to define an expanded program to include, for example, passive solar devices, thermal shutters, insulation, thermally resistant building elements, heat recuperator systems, siting studies and "energy budget" standards for buildings applicable as part of the building plans for approval.

The Program Convenor is:

Dr. D.G. Stephenson,  
Division & Building Research,  
National Research Council,  
Montreal Road,  
Ottawa, Ontario,  
K1A 0R9  
  
613-993-1421

#### 1.2 Transportation

This Program is mainly directed towards energy conservation by increased energy efficiency in transport technology and systems use. Other issues in the Program are interfuel substitution, emergency preparedness and specifically Canadian transportation problems. As much as possible, work is done in cooperation with industry.



There are six Subprograms, each with a number of projects and project areas. Work in the Automobile Subprogram (1.2.1) concerns setting performance standards, test methods and other ways of increasing automobile use efficiency.

Passenger Systems (1.2.2) has several projects dealing with aircraft in which there is close cooperation with the relevant industries. Other effort is directed at improving the efficiency of moving people within and between urban centres using the various transport modes.

In Freight Systems (1.2.3) the work is concentrated mainly on the operational aspects of moving freight. Retrofit devices from both the technical and policy viewpoints are being developed.

The Alternative Energy Forms Subprogram (1.2.4) has been developed in cooperation with the carriers and coordinated with similar research in Canada and the United States. The work includes technology assessments of various types of fuels and engines.

Data Analysis, Forecasting and Intersectoral Studies (1.2.5) provides the statistical and monitoring support for the overall Program. Program development (1.2.6) coordinates, reviews and evaluates the Program.

The Program Convenor is:

Mr. W. Johnson,  
Strategic Studies Branch,  
Transport Canada,  
Podium Building - 4th Floor,  
Place de Ville,  
Ottawa, Ontario,  
K1A 0N5

613-996-9731.

### 1.3 Food Supply System

The two on-going Subprograms are in the areas of farm energy budgets (1.3.1) and the energy efficiency of mechanized equipment (1.3.2). The Program was expanded in 1978-79 to include projects on energy conservation in greenhouses (1.3.5), conservation in livestock buildings and crop drying (1.3.4). In addition, a start is being made on energy use in the food system beyond the farm gate (1.3.3).

The Program Convenor is:

Mr. P. Van Die,  
Engineering and Statistical Research Institute,  
Agriculture Canada,  
Ottawa, Ontario,  
K1A 0C6

613-995-9671.

#### 1.4 Thermal Wastes

This Program originally concentrated on district heating. In 1977-78 funds were spent on the development of a waste wood gasifier and power plant siting. In 1978-79, the Program was expanded to cover energy cascading, cogeneration, low grade heat utilization and heat exchange. Since most of the technologies in this Program are fairly well developed, the needs are for the application of these technologies to specific systems and elimination of the barriers to their adoption.

The Program Convenor is:

Dr. T. Ledwell,  
Conservation and Renewable Energy Branch,  
Energy, Mines and Resources,  
580 Booth Street,  
Ottawa, Ontario,  
K1A 0E4

613-995-1801.

#### 1.5 Municipal and Industrial Wastes

The work (1.5.1) in this Program is directed towards indirect energy conservation i.e., in recycling and reuse of municipal and industrial wastes such as paper, glass, rubber, metals and waste oils. In the first two years of operation the Program was geared to recovery and reuse systems with the federal government but has now expanded to cover commercial and industrial complexes and other levels of government. Studies on the utilization of combustible municipal waste for production of fuels and incineration with heat recovery have been conducted as in-house work by DOE. Also the Demonstration of Resource Energy Conservation Technology Subprogram (1.5.2) which is intended to accelerate development of new or adaptation of existing technology includes technologies for utilization of combustible municipal wastes.

The Program Convenor is:

Mr. D.S. Hay,  
Solid Waste Management Branch,  
Department of the Environment,  
Place Vincent Massey,  
Ottawa, Ontario,  
K1A 0H3

613-997-4334.

#### 1.6 Oil and Gas Consumption

The main thrust of this Program is the development of improved domestic heating systems, focussing on both oil and gas furnaces. Several furnace retrofit devices have been developed and a "retrofit package" is being examined. Prototype furnaces incorporating the "Blue Flame" burner are also being tested. Joint government industry work is continuing on fuel

combustion systems for multi-fuel industrial gas turbines. There is a joint project with FERA on improved efficiency of combustion of oil in industrial furnaces.

The Program Convenor is:

Dr. R. Thomson,  
Canada Centre for Mineral and Energy Technology,  
Department of Energy, Mines and Resources,  
555 Booth Street,  
Ottawa, Ontario,  
K1A 0G1

613-995-4044.

#### 1.7 Industrial Process

The Industrial Energy R&D Program (1.7.1) is designed to encourage and assist Canadian industry in undertaking R&D of new and improved processes and equipment that will increase the efficiency with which the industry will use energy in the production of goods and services. Assistance normally amounts to 50% of the estimated cost of an approved project. The technology developed should have general applicability and the applicant, while retaining ownership, should promote its widest possible transfer and use in Canada.

The Program Convenor is:

Mr. L. Hart,  
Technology Branch,  
Department of Industry Trade and Commerce,  
235 Queen Street,  
Ottawa, Ontario,  
K1A 0H5

613-593-7861.

#### 1.8 Energy Conversion, Storage and Hydrogen Systems

The contents of this Program are diverse. The objective is to address new problems in energy conversion which derive from the exploitation of new resources and storage of significant amounts of energy (1.8.1). Seen from another perspective, the Program deals with the efficient utilization of depleting fossil resources (particularly liquid hydrocarbons) and their eventual replacement by new energy carriers.

Subprogram 1.8.2 includes studies on the production, storage and use of hydrogen. R&D on heat pumps (1.8.3) has been included in this program. In 1980-81 heat pumps will be a separate Program.

The Program Convenor is:

Dr. J.B. Taylor,  
Division of Chemistry,  
National Research Council,  
Montreal Road,  
Ottawa, Ontario,  
K1A 0R6

613-993-2506.

## 1.9 Urban Form and Urban Operations

The Program is intended to identify the opportunities for reducing energy use inefficiencies in cities through modification to urban form and design for new and existing communities. It will take into account technologies such as district heating and garbage incineration with heat recovery.

Plans call for the definition of research and development needed for redesign and new designs of urban communities.

The Program Convenor is:

Mr. P. Favot,  
Research and Development Division,  
Canada Mortgage and Housing Corporation,  
Montreal Road,  
Ottawa, Ontario,  
K1A 0P7

613-746-4611.

## 1.10 Consumer Products and Lifestyles

This Program is designed to investigate the area of consumer products and lifestyles in order to identify ways and means of achieving direct and indirect energy and resource savings. Studies are directed at identifying and analyzing the potential for conservation arising from changes in the design, manufacture distribution and disposal of consumer products. Similar research is being conducted to analyze the potential for conservation advances in the consumer behaviour area, involving general consumer lifestyles, consumer product choice and product use.

The Program will be linked directly with the conservation policy and program development process. The work is directed towards the achievement of the following goals:

- to develop a rigorous and comprehensive understanding of the realizable conservation potential in the consumer products and lifestyles area
- to perform policy and program analysis research in areas with a high potential for conservation gains
- to supply consultative services in the development and implementation of consumer conservation programs
- to carry out evaluation research studies of pilot conservation programs.

The Program Convenor is:

Mr. L. McCabe,  
Consumer Research and Evaluation Branch,  
Consumer and Corporate Affairs Canada,  
17th Floor, Place du Portage,  
Hull, Quebec  
K1A 0C9

613-997-1741.



Task: Conservation  
Program: Buildings  
Subprogram: Energy Conservation Standards for New Buildings

#### OBJECTIVE

To develop energy conservation model codes and standards for new buildings.

#### WORK

In 1976 the National Research Council's Associate Committee on the National Building Code established a Standing Committee to develop model codes for energy conservation in buildings. This semi-prescriptive type of model code for energy conservation in new buildings was issued in June 1978.

The Standing Committee has started to prepare an energy budget type of code, which will eventually replace the semi-prescriptive code. Work is underway to develop better methods of predicting and monitoring energy use in buildings so that they can be used in conjunction with the energy budget code. Work is also underway to establish a basis for setting energy budgets for four classes of buildings: offices, schools, apartments and shopping centres. Other classes of buildings will be considered later.

The energy conservation codes provide the vehicle for implementing the results that have been and will be obtained from all the other Subprograms in Program 1.1. This work is in direct support of the objective to stabilize the level of energy use in the building sector over the period 1975-1990.

Assessment of the methods for predicting energy consumption is being carried out on a multinational basis under the aegis of the IEA. The NRC is participating in this activity on behalf of the federal government.

The funds below are for Subprograms 1.1.1 and 1.1.5

78-79 Funds: \$475,000

79-80 Funds: \$745,000

Subprogram Director: Mr. J.K. Latta, Division of Building Research, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-1421

Task: Conservation  
Program: Buildings  
Subprogram: Air Tightness of Buildings

## OBJECTIVE

This Subprogram has two objectives: to develop procedures and data that will enable designers to predict the amount of energy lost from buildings due to air leakage; and to determine the reduction in air leakage that can be achieved by using different techniques for making buildings tighter.

## WORK

The exfiltration of air from buildings and the associated infiltration or deliberate supply of outside air accounts for up to 50% of the heat loss from a tall building, and 25 to 30% of the heat loss from a low-rise building.

Techniques have been developed for measuring the air tightness of tall buildings and these have been used to check the air leakage of office buildings and schools. Wind tunnel tests were carried out by the National Aeronautical Establishment to determine the pressure distributions that are caused by wind action on tall structures, and a procedure has been developed to use these data to predict air leakage rates for tall buildings. A paper was presented on this work at an annual meeting in Halifax in June 1977.

The Associate Committee of the National Building Code has requested NRC to investigate the feasibility of having an air leakage test as part of the performance requirement in the Energy Conservation Code. A simple pressurization test procedure has been developed and tried out on a small number of houses. A large scale trial determined the cost that would be involved if this test were used to check all new houses. The results also indicate the air tightness that is being achieved with current building techniques.

NRC has also developed a tracer gas technique for monitoring the rate of air leakage from buildings under normal operating conditions.

The International Energy Agency has a project on air infiltration and methods of testing buildings for air leakage in which the NRC is participating on behalf of the federal government.

78-79 Funds: \$200,000

79-80 Funds: \$230,000

Subprogram Mr. G.T.Tamura, Division of Building Research, National Research  
Director: Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-1421

1978-80

Task: Conservation  
Program: Buildings  
Subprogram: Building Lighting

#### OBJECTIVE

This Subprogram is aimed at establishing the actual profile of energy use by lights in different classes of buildings (initially schools and offices) and how these profiles are related to the type of switching and/or automatic control that is employed. These data are required to determine the appropriate energy budgets for different types of buildings, and how to minimize energy use by lights without sacrificing the quality of the inside environment.

#### WORK

There is a great potential for conserving electricity by improving the procedures for designing and controlling lighting systems. The lighting research program has concentrated initially on the control of lighting. Studies have been made to find out what level of saving can be achieved by using an automatic dimming system to adjust the artificial lights so that the total illumination (artificial plus daylight) never falls below a prescribed minimum level. In a perimeter office with average sized windows an automatic dimming control has been found to save over 60% of the energy that would have been used if the lights had been operated in the normal way. A similar check is underway in a school library that has daylight entering through skylights.

A simple instrument has been developed to record the hours of use of artificial lights in a room. These instruments will be used to determine the savings that result from the use of various innovative light control schemes. This device was developed by a private sector R&D organization working under contract to NRC. Subsequently, a small Canadian instrument company produced 200 units for use in the lighting research program. This company is now preparing to market the device both in Canada and abroad. There are indications that it will be useful in connection with energy management programs as well as in research.

Another contract has recently been awarded to a R&D organization to develop a microprocessor based lighting control system for large buildings. This project will likely continue into FY 80/81.

The NRC and the Illuminating Engineering Research Institute in the United States are jointly sponsoring a study of the benefits that might be obtained by using plane polarized light for illuminating certain tasks. This is a first step into the areas of basic research in vision and visibility. This type of study is essential if the maximum saving of energy is to be obtained.

78-79 Funds: \$250,000

79-80 Funds: \$560,000

Subprogram Director: Dr. D.G. Stephenson, Division of Building Research, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-1421

Task: Conservation  
Program: Buildings  
Subprogram: Residential Buildings

## OBJECTIVE

To calculate the energy needed to heat a house.

## WORK

The experimental work on energy conservation in houses has concentrated on the studies on air leakage described under 1.1.2, and work on measuring heat loss from basements. The basement studies have required the development of a calorimeter that can be used to measure the heat loss through a 4 ft x 8 ft section of basement wall or floor. Eighteen of these calorimeters have been deployed at sites in P.E.I., Ottawa and Saskatoon. Three test basements were constructed in Ottawa and are in use to study heat losses from basements with different arrangements of insulation. The objective of these studies is to obtain data that can be used to validate new computation procedures for predicting heat losses from basements. The test basements have already shown that water movement through the soil has a much greater effect than had been expected.

The other major activity in this Subprogram is the joint NRC/HUDAC four-house project at Orleans, Ontario. HUDAC constructed 4 houses; one conforming with the Ontario Building Code and the other three meeting the requirements of the new Model Code. The primary objective of this project is to obtain data on energy use in houses that can be used to validate the ENCORE CANADA computer program. A secondary aim is to check whether there are any unforeseen problems that arise as a result of making the houses tighter and using more insulation than has been normal up to now.

The ENCORE CANADA program and three new United States programs for analyzing energy systems in large buildings were presented and compared at the Third International Symposium on the Use of Computers for Environmental Engineering related to Buildings that was held at Banff in May 1978.

78-79 Funds: \$385,000

79-80 Funds: \$414,000

Subprogram Director: Mr. G.P. Mitalas, Division of Building Research, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-1421



1978-80

Task: Conservation  
Program: Buildings  
Subprogram: Non-residential Buildings

#### OBJECTIVE

To calculate the energy consumed by nonresidential buildings and to investigate the use of computers to control energy systems.

#### WORK

The work on nonresidential buildings had been mainly on office buildings and schools, and had focused on the problems that have to be solved before a performance type of energy conservation code can be implemented. These are: the method of analysis that should be used to determine energy consumption at the design (i.e., preconstruction) stage; the method of monitoring after the building is in use; and the development of information that can be used to establish energy budgets for different classes of nonresidential buildings.

The activity in this Subprogram is entirely related to the energy budget code described in 1.1.1, therefore, it has been amalgamated with 1.1.1.

For funding see 1.1.1

Subprogram Mr. J.K. Latta, Division of Building Research, National Research  
Director: Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-1421

Task: Conservation  
Program: Buildings  
Subprogram: Test Methods and Standards for Insulating Materials and  
Building Enclosure Assemblies

#### OBJECTIVE

To develop test methods and standards for insulating materials and building enclosure assemblies.

#### WORK

The research work on test methods and standards for insulation has been concentrated on ureaformaldehyde (UF) foam and cellulose fibre (CF) as these materials are relatively new in Canada and offer considerable promise for use in reinsulating existing buildings as well as in new construction. Provisional standards have been prepared for both of these materials by the CGSB. NRC has been involved in testing a series of wall panels insulated with UF foam at different stages during the dry-out (and shrinking) period following the placing of the foam in wall cavities. These tests have been used to establish the insulating effect that can be expected from this type of insulation in a wall as opposed to a sample that is tested in a standard thermal conductivity apparatus.

NRC has developed a method of producing samples of the CF insulation for thermal conductivity testing; these samples have a density corresponding to the density in a ceiling after it had settled for several months (or years). The NRC procedure for producing samples has been incorporated in the CGSB specification for this material. NRC has also carried out a considerable amount of testing on CF to assist the CMHC in assessing the quality of material that is on the market in Canada. The standard for this material includes requirements related to corrosivity, fungus growth and flame spread as well as thermal performance. Materials that meet all aspects of the provisional standard have been accepted by CMHC for use in ceilings in both new and existing buildings.

There are doubts about the use of this material in walls - especially existing walls that do not have a good vapour barrier on the inside surface. Additional work both in the lab and in the field is planned to try to resolve whether CF should be permitted for use in walls of older buildings.

78-79 Funds: \$350,000

79-80 Funds: \$524,000

Subprogram Director: Mr. K.R. Solvason, Division of Building Research, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-1421

1978-80

Task: Conservation  
Program: Buildings  
SubProgram: Air Quality

#### OBJECTIVE

This Subprogram is directed toward establishing the minimum amount of outside air that is needed to maintain acceptable air quality in different types of occupancies.

#### WORK

A pair of test rooms has been built in the NRC environmental laboratory. These rooms are equipped so that the amount of outside air and recirculated air can be varied over a wide range. The construction of the facility and purchase of instrumentation was done in 1977-78. This facility will be used for doing research with human subjects to assess factors affecting air quality and human comfort.

78-79 Funds: \$60,000

79-80 Funds: \$30,000

Subprogram Mr. G.T. Tamura, Division of Building Research, National Research  
Director: Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-1421

Task: Conservation  
Program: Transportation  
Subprogram: Automobile (Sheet 1 - Instrumentation and Applications;  
Technology Assessment; Alternative Engines)

## OBJECTIVE

To develop fuel economy test instrumentation; to assess automobile fuel economies; and to investigate the potential for "broadcut" and alcohol fuel engines.

## WORK

Three components are described on this sheet:

- An instrumentation package has been developed to simultaneously measure and record variables to characterize a vehicle journey and temperature conditions, all modes of acceleration, and near instantaneous fuel economy. Six units are planned to support an applications program which includes correlation of real time data with results of dynamometer tests; fuel performance as a function of Canadian weather conditions; fuel economy in relation to vehicle maintenance; fuel efficiency resulting from various technical modifications; optimization of urban traffic flow with respect to energy consumption; vehicle performance resulting from use of new fuels/blends; and comparative assessment of two and four stroke diesels in urban buses.
- The major activity in technology/fuel economy is the testing of select vehicles of different combustion technologies under representative Canadian climatic conditions. On-road performance of these vehicles has also been assessed under both winter and summer driving conditions. Work for 1979-80 continues this activity and efforts are being made to coordinate the work program more fully with complementary United States initiatives. Six late-model automobiles, using new technology, have been road tested using four driving test cycles under spring, summer and winter temperature conditions. Results showed considerable degradation of fuel efficiency with gasoline engines, less with diesel engines. Continuing work will include further evaluation of vehicles with advanced combustion control using spark ignition or compression and evaluation of lead traps for reduction of lead emissions.
- End-use technologies necessary to use "broad-cut" and alcohol fuels are being identified. Two projects in progress are: An investigation of the effects of diesel fuel components on diesel engine performance and cetane rating; and an assessment of diesel engine performance on a range of synthesized broad cut fuels representative of the maximum availability cut from foreseen future refinery crude stocks.

(continued on next page)

1978-80

Task: Conservation  
Program: Transportation  
Subprogram: Automobile (Sheet 1 - Instrumentation and Applications;  
Technology Assessment; Alternative Engines)

(continued from previous page)

A prototype engine designed for operation on alcohol fuel will be both laboratory and road tested to establish performance characteristics at ambient temperature on both chemically pure methanol and on methanol with additives to simulate wood alcohol derived from forest biomass. Cold starting tests will be made at temperature to  $-30^{\circ}\text{C}$ , with the exploration of fuel additives to assist cold start and engine conditions optimized for cold starting.

Some of the above work is being done at EMR. The contact there is Dr. R. Thomson, Canada Centre for Mineral and Energy Technology, Department of Energy, Mines and Resources, 555 Booth Street, Ottawa, Ontario. K1A 0G1. 613-995-4044.

The funds below are for all of Subprogram 1.2.1

78-79 Funds: \$524,000

79-80 Funds: \$ 670,000

Subprogram Director: Mr. G. Maund, Strategic Studies Branch, Transport Canada, Podium Building - 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5. 613-996-9731.



Task: Conservation  
Program: Transportation  
Subprogram: Automobile (Sheet 2 - Maintenance; Retrofit)

## OBJECTIVE

To determine relationship between "state of tune" and fuel consumption characteristics; to improve fuel economy through better vehicle design or maintenance procedures; and to assess the feasibility retrofitting engines to improve fuel efficiency.

## WORK

Two components are described on this sheet:

- Current estimates indicate that improved maintenance procedures in support of fuel economy would be applicable to 60% of the fleet resulting in a fuel saving of approximately 1%. The project for 1978-80 is to carry out a test program for 'as found' vehicles in order to correlate state of tune with emissions and fuel economy. Based on the results of this phase, consideration will be given to the feasibility and desirability of instituting a vehicle maintenance program or to promoting other measures to improve or maintain fuel economy performance throughout the operating life of the vehicle. Projects for 1979-80 are: correlate state-of-tune with fuel economy; survey of vehicle maintenance profiles.
- In order to assess the performance of available retrofit (after market) devices and the potential for improving fuel economy through retrofit generally, work for 1978-80 is to: evaluate promising commercially available devices and to develop recommended test procedures for the conduct of demonstration projects.

For funding see 1.2.1 (Sheet 1)

Subprogram Mr. G. Maund, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

Task: Conservation  
Program: Transportation  
Subprogram: Automobile (Sheet 3 - Hybrid Vehicles; Dieselization)

## OBJECTIVE

To develop information on hybrid vehicles; and to determine the desirability and feasibility of accelerating the introduction of diesel engines

## WORK

Two components are described on this sheet:

- The potential of hybrids (powered from engine and energy storage devices) to improve fuel economies is high. The diesel/inertial flywheel project is intended to design, construct and rig test a diesel/flywheel hybrid drive train employing a continuously variable transmission (CVT). All major components have been defined and purchased. A computer systems analysis program has shown that overall achievable energy saving would be more sensitive to flywheel assembly losses and to CVT efficiency (in the regenerative mode). During 1979-80, the test rig was used to obtain the static and dynamic response to each component and a successive combination of components in a drive train in order to evaluate their interaction, control and transmission characteristics. This is being followed by an assessment of overall energy saving prospects and the system optimized for installation in a bus for road tests and demonstration purposes in 1980-81. Another project looks into the concept of an urban vehicle having an internal combustion engine and hydraulic drive which means an hydraulic reservoir for storing braking energy and releasing it on subsequent acceleration. Steady state runs have been completed and the electronic controls of the dynamometer system have been modified to simulate road conditions and to test the transient operation of the control system and the fuel economy of the diesel/hydraulic drive system. A vehicle and components for a prototype road vehicle have been purchased.
- A study was initiated in 1977-78 aimed at investigating the energy conservation potential of diesel powered medium duty trucks in Canada. This work continued through 1978-79. In order to more generally assess the feasibility of accelerating introduction of diesel engines into automotive fleets the following additional projects for 1978-80 are: impact of increasing demands for diesel fuel on refineries; and analysis of diesel engine cetane requirements with particular reference to low temperature start capabilities.

For funding see 1.2.1 (Sheet 1)

Subprogram Mr. G. Maund, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

Task: Conservation  
Program: Transportation  
Subprogram: Automobile (Sheet 4 - Cooling Systems; Lubricants)

## OBJECTIVE

To investigate the fuel economies of improved cooling system design; and to investigate the potential of low viscosity engine/gear oil (lubricants) to improve fuel economy with particular reference to Canadian conditions.

## WORK

Two components are described on this sheet:

- The Engine Laboratory at NRC, in cooperation with an automotive fan and automobile manufacturer, has developed a test program to assess performance of fan/radiator/cooling systems with particular reference to the ram effects on the cooling fan. Improvements in fan aerodynamics together with fan unloading at high speeds could improve fuel efficiency by about 1%. An appropriately instrumented vehicle has undergone wind tunnel testing and results have been correlated with on-road test data. The activity for 1978-80 concentrated on the selection, design, manufacture and testing of experimental fan types suitable for direct replacement of the conventional axial fan in the instrumented test vehicle.
- The Fuels and Lubricants Laboratory at NRC has seen the need to define fuel efficient engine lubricants by establishment of reference oils and acceptable test procedures. This need is reflected by recent efforts of the SAE and the ASTM to define an appropriate set of parameters and apply them. The work for 1978-79 coordinated with these and other related initiatives and emphasized cold weather aspects of lubricant energy losses - areas generally neglected in work to date. Projects done during 1978-80 were: assessment of reduced energy loss with continued satisfactory lubrication performance of various gear lubricants under Canadian conditions (low temperatures); and development of test procedures and subsequent testing of specific classes of gear oils.

For funding see 1.2.1 (Sheet 1)

Subprogram Mr. R. Whyte, Division of Mechanical Engineering, National Research  
Director: Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-2415.

Task: Conservation  
Program: Transportation  
Subprogram: Automobile (Sheet 5 - Fuel Economy Policy Development)

## OBJECTIVE

To identify and assess various policy measures aimed at promoting efficient use of automobiles; and to determine the range of technically and economically feasible improvements in fuel economy.

## WORK

A variety of projects, including most of those reported elsewhere in Subprogram 1.2.1, are aimed at improving the fuel economy of automobiles. This array of options and efficiency claims must be focused on measures which government can legitimately take to meet this goal. This policy-oriented research perspective is essential to management of the Program if the results are to be readily transformed into useful measures.

One part of this approach is an assessment of the potential fuel economy of the automotive fleet based on technical and economic factors. The other identifies and assesses specific policy measures and identifies other areas for research as needed. It is important that this project be comprehensive and include considerations (beyond technical and economic feasibility) such as market response, cross impact of standards, and international trade/manufacturing patterns.

Projects are: fuel economy forecast; identification and assessment of policy measures; and transfer of results of United States policy related R&D.

For funding see 1.2.1 (Sheet 1)

Subprogram Director: Mr. G. Maund, Strategic Studies Branch, Transport Canada, Podium Building - 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

Task: Conservation  
Program: Transportation  
Subprogram: Automobile (Sheet 6 - Measures to Promote Efficient Use)

## OBJECTIVE

To identify and assess a variety of systems measures aimed at promoting efficient use of the automobile.

## WORK

Two opportunities which have been identified for study and promotion are car pooling (particularly for the journey to work) and specialized vehicle sharing through car rental.

A major initiative to demonstrate car pooling for travel to work was attempted in Vancouver beginning in 1976. A series of car pool assessment projects has conducted simultaneous surveys and analyses to identify typical car pool user profiles and constraints and incentives to car pooling. A final project report was completed and the results indicate that car pooling to central business districts competes with transit and consequently it is recommended that car/van pooling be promoted outside that area in future.

Also, in 1979, a project to assess network traffic signal control strategies for minimal fuel consumption by automobiles was completed in cooperation with the Metropolitan Toronto Traffic Department.

The car rental industry is an unexplored option for energy savings in the automobile mode. There is limited data on present industry size, client profiles or energy efficiency and studies are planned to assess these factors.

For funding see 1.2.1 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.



1978-80

Task: Conservation  
Program: Transportation  
Subprogram: Passenger Systems (Sheet 1 - Energy Efficiency of Aircraft; Aircraft Energy Monitoring System; Intercity Air)

## OBJECTIVE

To develop data that will aid in the design of more fuel-efficient small transport aircraft and lead to power plants that are compatible with the Canadian aerospace industry; to develop a cost-effective system to optimize management of fuel consumption on commercial aircraft; and to assess the potential for improved energy efficiency of intercity air systems.

## WORK

Technical R&D to improve the energy efficiency of large commercial aircraft is being carried out in other countries, principally the United States, whereas Canadian industrial strategy is to concentrate on small commercial power plants and conventional and STOL aircraft. The work on fuel-efficient aircraft carried out in 1978-79 followed directly from the parametric studies completed previously. A three-year program was developed and the first phase of each of three projects was initiated. These projects include aerodynamic improvements to gas generator turbines suitable for small turboprop and turbofan aircraft engines. They include a study of wing and propeller airfoils using wind tunnel tests and design studies of STOL performance versus field size begun in February 1979. They also include a study of the performance of high aspect ratio wings with supercritical airfoil sections and of the relative merits of turbofan and prop-fan engines for small aircraft. The work for 1979-80 continued the first phase activities. The second phase of the aerodynamic study of gas generator turbines has been started. Work on the second phases of the wind tunnel tests and small aircraft performance studies has been started.

The second area of work was the development of an aircraft energy monitoring system using an in-flight engine thrust computing system, that took into account measureable variations in propulsion system performance between engines of the same type. This project was carried out in cooperation with industry who provided technical support on aircraft operating procedures and aircraft/engine performance data. The next phase of the project assessed the technical feasibility and economics of proceeding with the development of an AEMS. Initial work was based

(continued on next page)

1978-80

Task: Conservation  
Program: Transportation  
Subprogram: Passenger Systems (Sheet 1 - Energy Efficiency of  
Aircraft; Aircraft Energy Monitoring System; Intercity Air)

(continued from previous page)

on an evaluation of a Lockheed L-1011 aircraft then extended to Boeing 727 and 747 aircraft. Although certain operational changes were identified that could improve the fuel efficiency of these aircraft, it was concluded that the excellent engine instrumentation installed on these aircraft did not warrant development of an AEMS system for the aircraft using inflight thrust measurements. This study has indicated that present procedures and instruments are adequate to plan and execute optimum fuel consumption flight profiles for aircraft and has been a model of cooperative research combining government, manufacturer and carrier interests. The work was finalized in 1979-80.

Intercity air systems was a new Project area in 1979-80. Related work carried out in 1978-79 assessed the energy impacts of proposed strategies for expansion of air passenger services in southern Ontario. This work established data sources and methodologies directly applicable to a study of the national air system. The work in 1979-80 began to develop a simulation model of the national air passenger system to be used to assess the energy and level of service impacts of forecast demand increases and selected regulatory and other policy measures.

The funds below are for all of Subprogram 1.2.2

78-79 Funds: \$380,000

79-80 Funds: \$435,000

Subprogram Director: Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

1978-80

Task: Conservation  
Program: Transportation  
Subprogram: Passenger Systems (Sheet 2 - Intercity Intermodal)

#### OBJECTIVE

To identify, assess and where appropriate, implement measures which will encourage passengers to use more energy efficient modes; and to ensure that energy efficiency considerations are included in policies for multimodal transport corridors.

#### WORK

In 1977-78 a contract was let to establish a base of multimodal passenger energy data. This considers the main corridors of intercity passenger transportation within and between the regions of Canada with associated international linkages. This data base also includes a summary of the energy impacts of recent multimodal transportation policy studies, technological and efficiency characteristics of passenger modes and relevant site specific data from recent years, 1970 to 1977. A benefit-cost methodology and case application project was also developed. The major focus of the work is the Quebec-Windsor corridor. A scenario approach to analysis of alternatives is planned and future work will investigate in detail the impacts of policy measures on demand for travel in the corridor.

The studies to date indicate that some potential exists to reduce transport energy consumption through intermodal shifts. However, the actual achievement of energy savings will have to deal with level of service changes and significant modal investment costs.

For funding see 1.2.2 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

Task: Conservation  
Program: Transportation  
Subprogram: Passenger Systems (Sheet 3 - Urban Transport Technology and Systems; and Van Pooling)

## OBJECTIVE

To encourage technical research and development on fuel economy on urban transport services and activities; to support systems oriented research and development; and to promote vanpooling for travel to work.

## WORK

The major technical work in 1978-79 concerned the development of a diesel/inertial hybrid drive system for urban transit vehicles. This project has since been transferred to Subprogram 1.2.1 Automobiles as the development of technology suitable for small vehicles is the ultimate goal of this project.

Systems research focussed on developing and promoting urban transport systems improvements which increase load factors and which expedite the smooth flow of traffic. The research studied: the energy implications of a demand responsive transport (DRT) service, and of a stop to stop DRT service for a large suburban region; energy impacts of shared ride taxi services and measures to promote efficient fleet operations; and assessment of energy impacts of investment in road and traffic control facilities on fuel economy of urban vehicle operations.

With respect to van pooling, work in 1978-79 began by contacting all the provinces in order to assist them in understanding the program and in determining how they could take part. Contracts were subsequently signed with consultants to conduct demonstrations in several provinces. The demonstrations involve about 30 vans on the roads. An evaluation will take place at the end of the one year demonstration and the report will be produced during 1980-81. Particular attention will be given to such issues as energy savings, the van pool market, attitudes to van pooling and changes in car ownership and operation.

For funding see 1.2.2 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.



Task: Conservation  
Program: Transportation  
Subprogram: Freight Systems (Sheet 1 - Intercity Road Technology;  
Intercity Road Operations)

#### OBJECTIVE

To develop the technology to conserve energy in intercity road transport; and to identify and assess energy-saving measures affecting the operation of intercity freight systems.

#### WORK

Work which correlated on-road and wind tunnel trials of aerodynamic drag reduction devices for trucks has shown a potential fuel saving of between 7%-17% for certain front mounted deflectors and indicated further types of antidrag designs for investigation. In 1978-79 the results of the trials were published in the technical press and a brochure distributed to truckers by the Canadian Trucking Association. Subsequent wind tunnel tests evaluated more accurate scale models of the road test vehicles and their deflection devices. Some combinations of devices show that additional fuel savings could be achieved with the development of new add-on designs, or by modification to the front corners of a trailer. During 1978-79, liaison was established with the U.S. DOT Truck and Bus Fuel Economy Study.

Work in 1979-80 continued wind tunnel tests with both current truck and trailer profiles and advanced profile designs. Four truck models were produced by NRC for wind tunnel testing.

Work started 1978-79 on over-the-road measurements of truck rolling resistance for the assessment of energy losses and then correlation to laboratory derived data. The test program is complementary to a United States Department of Transport sponsored series of tests being made at the Calspan Laboratory. Liaison is effected by United States Department of Transport representation on the Steering Committee.

Intercity road transport is significantly affected by operational, regulatory and market conditions. Inefficiencies result from empty backhaul movements, low truck loadings, and low gross vehicle weight limits. This research is aimed at analyzing road operations to identify changes which can be made in regulatory measures and operational conditions to improve overall energy efficiency. This work will be coordinated with provincial governments who are responsible for road transport to ensure implementation of results in the post 1980 period.

The funds below are for all of Subprogram 1.2.3

77-78 Funds: \$260,000

79/80 Funds: \$484,000

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.



Task: Conservation  
Program: Transportation  
Subprogram: Freight Systems (Sheet 2 - Intercity Rail Technology;  
Operations; Intermodal Freight)

#### OBJECTIVE

To develop fuel-conserving rail freight car and locomotive technology; to improve rail system energy conservation measures; and to compare the energy consumptions of alternative door-to-door intercity freight services.

#### WORK

A review of the design and operating factors which influence energy consumption by railway freight cars covered material content, rolling resistance and air drag factors and identified areas where improvements could be made. The impediments to implementation of technical improvements are initial car costs, financial and accounting constraints and low fleet turnover rates. Retrofitting of existing fleets of rail cars might overcome this latter problem.

The same review found that accurate fuel consumption data of locomotives are lacking and that, although the diesel engine is inherently efficient, improvements in design can improve fuel performance by approximately 10%. Continuing projects include: development of locomotive fuel consumption and work output data acquisition system and collection of over-the-road fuel performance data; and identify and assess new fuel efficient locomotive engine designs. With rail intercity freight accounting for 6% of total annual transport energy consumption, even marginal improvements in fuel efficiency can lead to large overall savings.

A review of United States and Canadian railway energy conservation practices indicates that the national railway companies have begun to implement energy conservation practices and to record significant savings, particularly in the non-operating aspects of railway systems. A project has begun on the development and application of a data acquisition package to accurately measure locomotive fuel consumption. A project to develop and test a prototype steerable freight car truck was identified as a significant measure to improve rail fuel efficiency especially in heavy unit train operations such as coal transport (see Program 5.1).

A study is underway, with the cooperation of the road & rail carriers, to measure and evaluate all the factors which affect fuel consumption in competing road and rail freight services such as over the road line haul and empty back haul movements, pick up and delivery, loading and unloading operations, yard and terminal operations and ancillary supporting services.

For funding see 1.2.3 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

1978-80

Task: Conservation  
Program: Transportation  
Subprogram: Freight Systems (Sheet 3 - Urban Goods Movement)

#### OBJECTIVE

To promote technical and operational measures to conserve energy in urban goods movement.

#### WORK

The movement of goods in urban areas is energy inefficient compared to intercity freight because of low load factors and the low speed, stop and go operation. The barrier to improvements in energy efficiency are technological (prevalence of gasoline powered vehicles), institutional (prevalence of private carriage), high service requirement, relatively high total cost and small energy cost, traffic congestion, the nature of services rendered (multiple delivery), road geometrics, route network, traffic control, financial costs of changes.

Results of a study entitled "Potential Energy Conservation in Urban Commodity Flow" have been reviewed and the report prepared for general distribution. A new study "The Economics of Urban Goods Movement" was done in collaboration with the Urban Transportation Research Branch. The purpose of this study is threefold: to describe the urban goods movement industry; to develop and test a methodology for analysing the effects of government-initiated changes affecting the operational conditions within the urban goods movement industry, and to determine the importance of specific changes for the urban goods movement industry and for the total urban transportation system. Energy considerations have an impact on each of these three items.

For funding see 1.2.3 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

Task: Conservation  
Program: Transportation  
Subprogram: Freight Systems (Sheet 4 - Marine)

#### OBJECTIVE

To support research directed toward improving fuel economy of marine transport systems.

#### WORK

Work in 1978-79 and earlier years concerned design of a combined cycle gas turbine installation for marine use. Waste heat from the gas turbine generates steam which drives a steam turbine which augments the output of the gas turbine.

Also, investigations were made into the applicability of the rules and the requirements of two major ship classification societies and of federal government legislation and regulatory bodies for the above type of propulsion plant and service. Component specifications for boilers, steam turbines and condensers were compiled and used in consultation with manufacturers to determine the feasibility of this type of propulsion system, from the aspects of component availability, size, weight, cost and cost effectiveness in operation. Enquiries were made to establish the capability of manufacturers to design and produce the mechanical drive train components suitable for the power requirements while conforming with the design criteria of the Arctic Waters Pollution Prevention Regulations. Market surveys were conducted into the marine application potential of these propulsion plants from which a typical ship and operating profile was derived on which to base further studies.

The other phases of this work are engineering investigations to prepare specifications for a combined cycle marine propulsion system after which the results will be available to marine engine manufacturers as an energy efficient design option.

For funding see 1.2.3 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

1978-80

Task: Conservation  
Program: Transportation  
Subprogram: Alternative Energy Forms (Sheet 1 - General Assessment)

## OBJECTIVE

To assess alternative energy sources for transport; investigate characteristics of propulsion systems in the context of adopting alternate energy sources; assess impact of potential transitions in energy forms on the transport sector.

## WORK

Although various estimates have been made of possible contributions to energy supply from non-conventional sources it is now necessary to comprehensively and systematically identify and investigate the full range of alternatives simultaneously. This will permit a balanced approach to policy development particularly in directing uses of specific energy forms to specific markets and in supporting a strategy for alternative fuels development in Canada. Continuing projects include identification and assessment of candidate alternate energy form options for transport; identification and assessment of potential alternate propulsion systems for transport in the context of alternative fuel developments; review of alternate fuel programs in other countries and assessment of implications of these developments for the Canadian transport sector; and comparative systems analysis of promising options with particular reference to the Canadian resource base, operational requirements of various modes, distributions and storage problems, and characteristics in end-use.

A review of some 15 energy options to date has underlined attractiveness of liquid fuels. In terms of resource base, economics of distribution and storage, safety, industrial dislocations and impacts on end-users, liquid fuels for transport consistently rank higher than non-liquid fuel options.

The funds below are for all of Subprogram 1.2.4.

78-79 Funds: \$0

79-80 Funds: \$340,000

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.



GOVERNMENT OF CANADA

1978-80

Task: Conservation  
Program: Transportation  
Subprogram: Alternative Energy Forms (Sheet 2 - Conventional  
Fuels/Non-Conventional Sources; Alcohols; and Hydrogen)

## OBJECTIVE

To investigate the potential for production of conventional fuels from non-conventional sources; to investigate their characteristics in end-use; and to assess the potential use of alcohol fuels and hydrogen.

## WORK

Specification or near-specification fuels from non-conventional sources: The feasibility of producing these fuels and the effect of changing fuel specifications on the operations of the various transport modes is being studied. Experiments with off-spec fuels in test engines have shown how specifications of rail diesel can be altered without affecting performance. Similar work is being done on the air and road mode. A major accomplishment is the agreement of the carriers and the U.S. government in many cases to coordinate their work in these areas.

Evaluation of Methanol/Gasoline Fuel Blend: This is a study of the application of methanol and gasoline fuel blends as a contingency or alternative fuel for automobiles. It assesses fuel economy and effects of driveability resulting from the susceptibility of these fuels to separate in the presence of moisture. Vehicles with advanced combustion engines have been selected to ensure that the results can be used in the future automobile fleet. The project will make recommendations on the use of fuel blends having up to 15% methanol. The project is operated by the Ontario Ministry of Transportation and Communication who is providing part of the funding. It has a steering committee with NRC and EMR representation which keeps the Motor Vehicles Manufacturers Association and the Canadian Automobile Association advised.

Development of a Methanol/Gasoline Fuel Emulsifier: This project is aimed at an era where methanol may be available in quantity as an alternative automobile fuel in which case there would be a need to introduce methanol beyond the approximate 15% limitation acceptable in current automobiles. The design of a retrofit device capable of emulsifying methanol and gasoline in a higher methanol proportion than 15% is to be researched, assessed in an engine test bed, and later used in on-road trials. Such a retrofit unit would permit greater mobility between areas of different methanol availability and allow existing fleet stock to be used more effectively on a methanol rich fuel blend whilst dedicated alcohol engines are being marketed. The device would allow up to 40% displacement of gasoline on vehicles fitted with the device.

(continued on next page)



Task: Conservation

Program: Transportation

Subprogram: Alternative Energy Forms (Sheet 2 - Conventional  
Fuels/Non-Conventional Sources; Alcohols; and Hydrogen)

(continued from previous page)

Assess Potential Uses of Hydrogen as an Energy Source for Transport:

While hydrogen has been identified as a fuel of interest to transport, a minimal amount of work will be carried out primarily because it is generally viewed as a long range option. The hydrogen option will be dealt with to some extent in 1.2.4 (Sheet 3). Activity in this area will serve to monitor developments in other countries. Canada has been asked to endorse the hydrogen option for inclusion in the joint rail program with the United States.

For funding see 1.2.4 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

Task: Conservation  
Program: Transportation  
Subprogram: Alternative Energy Forms (Sheet 3 - Electrical/ Electrochemical)

#### OBJECTIVE

To examine and promote, where applicable, the use of electrical/electrochemical energy in transportation.

#### WORK

The work is currently divided into three areas:

- Direct Electrification: Options for direct electrification have been identified principally in the areas of urban transit and guided intercity transport. A study has been completed which investigated the feasibility of railway electrification. The conclusions are that technologies are available to meet Canadian needs but that additional analyses are required to determine those most acceptable and cost effective. The cost under various options however remains a major problem as well as renewed policy questions about the role of railways and the desirability of moving transport off oil.
- Electrochemical Storage: A major study has been completed aimed at investigating the feasibility of utilizing electric vehicles (e.v.) in Canada. The major conclusions of the report are that viability of e.v. will depend on battery developments, certain hybrid vehicle options may help resolve battery performance limitations, and e.v. may perform adequately for the small commercial and transit vehicle market but at higher operating costs than internal combustion engine vehicles. An e.v. demonstration program has been approved. The need for a battery development component was particularly noted.
- Fuel Cells: Fuel cells have been of limited interest to transport primarily because of cost, size/weight and fuel handling problems. However, the potential advantages of these power sources warrant an assessment of transport applications.

For funding see 1.2.4 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

Task: Conservation  
Program: Transportation  
Subprogram: Alternative Energy Forms (Sheet 4 - Multi-fuel Engines)

#### OBJECTIVE

To test and evaluate propulsion systems capable of using a broad range of fuels with particular reference to the Stirling engine.

#### WORK

Engines with a capability to use a range of fuels are attractive for transport applications primarily because of the security which a diversified fuel base affords, but also because it theoretically permits optimization of total fuel supply/end-use systems. An investigation of the broad-cut option for diesel engines and alcohol fueled engines is being funded elsewhere (1.2.1 Sheet 1).

Activities in this project area consist of reviewing developments of multi-fuel engines and developing an acquisition/test strategy for subsequent years. Initial studies will concern the capabilities and limitations of the Stirling engines.

For funding see 1.2.4 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

Task: Conservation  
Program: Transportation  
Subprogram: Data Analysis, Forecasting and Inter-Sectoral Studies (Sheet 1 - Energy Consumption Monitoring; and Surveys and Fleet Analysis)

#### OBJECTIVE

To relate output, energy consumption and efficiency in Canadian transportation; and to determine the nature and level of automobile and road vehicle use and associated fuel consumption.

#### WORK

Two components are described on this sheet:

- This project defines a transportation energy consumption monitoring system. An initial monitoring report completed in November 1978 summarized energy supply, energy consumption by mode and activity within mode, types of fuel consumed, price (indices) of fuels, level of service by mode, and indicators of energy efficiency by mode. Another project, to catalogue and analyze the direct use of energy by transport in the Atlantic provinces, has been completed. It analyzed trends and presented a range of estimates for future energy consumption in the region. Continuing projects are: development and publication of energy monitoring system report; and direct energy studies in Quebec, Ontario and the western provinces (as per Atlantic).
- Development has begun on statistical procedures to capture data on automobile use and will apply this methodology to develop time series data on the composition of the automobile fleet, user trip characteristics, vehicle miles travelled, fuel consumption efficiency, fuel consumption, price paid for fuel and other related factors. This involves an automobile fuel consumption study.

Funding support has been provided to Statistics Canada's Labour Force Survey (Travel to Work Supplement) to obtain energy consumption by commuters. Also, energy related flow data from the Intercity Travel Survey by Statistics Canada will lead to energy related questions on later surveys.

The funds below are for all of Subprogram 1.2.5

78-79 Funds: \$345,000

79-80 Funds: \$534,000

Subprogram Director: Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

Task: Conservation

Program: Transportation

Subprogram: Data Analysis, Forecasting and Inter-Sectoral Studies (Sheet 2 - Forecasting; and Transport Sector Price Response)

#### OBJECTIVE

To provide forecasts of energy requirements in the transportation sector; and to assess the response of transport sector components to changes in price structures related to transport.

#### WORK

Two components are described on this sheet:

- A study has produced an historical data base which describes fuel consumption by mode as a function of output, thus establishing a basis for forecasting future fuel requirements given the demand for transport services and the price of fuel. This study confirmed that the demand for transport fuel is price inelastic. Another study related fuel consumption by passenger mode to the level of service offered by mode and by route.

An in-house study by the Strategic Studies Branch, Transport Canada monitored energy price and supply developments and forecasted future prices and supplies with particular reference to transport implications. A further study to assess the outlook for electricity in Canada with reference to its potential use by transportation systems has been completed. A report on natural gas as a substitute for petroleum based fuels has also been completed.

Projects for 1978-80 include: project future energy consumption by mode, by fuel for transport considering demand growth, supply replacement and technological improvements; and assess future energy supplies and prices from a transportation perspective.

It appears that electrical energy prices will increase in future roughly in line with increases in oil prices and will not provide a cheap alternative to oil. Natural gas can displace considerable quantities of light fuel oil which with further processing can be converted into transport fuels.

- Studies on the manner in which the transportation sector responds to price changes included projects on general analysis of pricing impacts and market share analysis.

For funding see 1.2.5 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.



Task: Conservation

Program: Transportation

Subprogram: Data Analysis, Forecasting and Inter-Sectoral Studies (Sheet 3 - Indirect Energy Use by Canadian Transport; and Industrial Location and Urban Form)

## OBJECTIVE

To determine the indirect energy costs of Canada's transport system; and to clarify industrial location and urban form relationships to urban transport energy consumption.

## WORK

Work done has estimated the indirect energy component of the transportation system and then added the direct energy component to evaluate the total energy efficiency of various transport modes. The next phase of the work consists of two major thrusts: the updating and refinement of the general approach to develop specific data on indirect energy use in particular circumstances (modes, policy/planning initiatives) as a function of industrial structure and industrial developments; and develop a methodology to identify trends in indirect energy costs and impacts of new developments in technology (substitute materials, recycling of materials, design factors) and assess energy economics of specific modes in future.

The work in the field of industrial location is a comprehensive review of location theory, incorporating energy considerations, to determine sensitivity of analytic results to prices and availabilities of specific energy forms and to identify industries significantly impacted by higher transport (energy) costs or most able to contribute to energy conservation through specific location decisions.

One part of the work on urban form is to correlate certain aspects such as urban services, residential/work locations, and the demand for energy for transport, to identify and assess potential for significantly reducing energy requirements based on modifications of existing urban environments and implementation of new urban development, and to identify key opportunities to implement results of analysis, e.g., new town development and significant urban developments. The second part of the work is to survey existing transportation facilities related to intercity/urban interface of Canadian cities (26 city analytic base), analyse energy requirements as a function of mode and use, and assess feasibility and design requirements for minimizing energy consumption.

For funding see 1.2.5 (Sheet 1)

Subprogram Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium  
Director: Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5.  
613-996-9731.

Task: Conservation  
Program: Transportation  
Subprogram: Program Development

#### OBJECTIVE

To develop a program evaluation system to monitor progress and provide future program direction.

#### WORK

Early phases of development of the federal energy R&D program, and Program 1.2 in particular, were characterized by efforts to undertake a large number of projects to cover off areas which were identified as providing opportunities to meet generally stated energy objectives. It would appear that this early growth was necessary in the past and must continue. However, it is also apparent that a process of program evaluation must be initiated which will: help to consolidate early program initiatives; monitor progress vis-à-vis established and evolving energy/transport policy objectives; and develop a basis for systematically identifying gaps and opportunities in the current program.

The work at present consists of: a review of program evaluation initiatives conducted elsewhere; a reassessment of R&D objectives and priorities; a review of criteria developed by Transport Canada earlier coupled with an evaluation of the manner in which these are being applied; and development of an articulated and comprehensive evaluation methodology.

78-79 Funds: \$0

79-80 Funds: \$56,000

Subprogram Director: Mr. W. Johnson, Strategic Studies Branch, Transport Canada, Podium Building, 4th Floor, Place de Ville, Ottawa, Ontario, K1A 0N5. 613-996-9731.

Task: Conservation  
Program: Energy Conservation in the Food Supply System  
Subprogram: Energy Budgets for Farms

#### OBJECTIVE

To assemble a data base on energy use patterns on Canadian farms in a form useful for assisting energy budgeting.

#### WORK

Work has been in these three components:

- Studying of information on field operations in the prairie region of western Canada and assessment of the need for additional research on energy conservation in cereal production. Recommendations for research are made under the following headings: Crop Improvement; Crop Management; Crop Protection; Soil, Equipment and Economics. The recommendations cover a broad range, but the main concern is with the new concept known as zero tillage. Topics include equipment to seed and apply fertilizers on land with a heavy trash cover, spreading of straw and chaff uniformly, effect of no tillage on soil characteristics, fertilizer practices as affected by zero tillage, and the effects of high levels of surface trash on diseases and insects. Other topics include increased emphasis on the biological nitrogen fixation, the use of light-weight diesel tractors, and continuation of the development of crop simulation models for all regions with particular attention to energy inputs under varying weather and moisture conditions.
- The study of the energy consumption of different agronomic practices on fourteen selected farms in Saskatchewan. The "innovative" farms, in comparison with the "conventional" farms, had lower fuel consumption per cultivated acre but also had slightly lower yields.
- A study of the output to energy input ratios for different crop and animal farming systems in Ontario. The results, on 29 crop and 7 animal systems, were prepared for publication as an Agriculture Canada Bulletin.

Work in this Subprogram was completed in 1978-79.

78-79 Funds: \$20,000

79-80 Funds: n.a.

Subprogram P. Van Die, Engineering and Statistical Research Institute, Agriculture  
Director: Canada, Ottawa, Ontario, K1A 0C6. 613-995-9671.

Task: Conservation  
Program: Energy Conservation in the Food Supply System  
Subprogram: Energy Efficiency of Mechanized Equipment

## OBJECTIVE

To develop more energy efficient mechanized farm equipment.

## WORK

Recent projects include:

- The design and development of a composite tractor drive wheel, and suitable control system to automatically control wheel slip under various soil conditions. A full-scale prototype was constructed and evaluated.
- The evaluation of improvement in energy efficiency of a Canadian developed concurrent flow grain drier in comparison with conventional crossflow driers. Trials were conducted on the concurrent flow grain drier using corn and white beans in Ontario and wheat in Manitoba.
- An evaluation of current discers to provide uniform depth of seeding was made. The field evaluation was used to make modifications to the general design of a prototype automatically controlled uniform seeding depth discer. Also the performance of commercially available seed drill openers were tested and evaluated with respect to soil flow around opener, furrow characteristics, soil seed contact, reaction forces on the opener and its ability to penetrate through trash. The improvement of seeders is contributing towards the reduction in the amount of tillage required thereby contributing to an improved ratio of crop yield versus energy input.
- Better implement depth control gives a more uniform crop yield and enables the establishment of the relationship among energy consumption, crop yield and tillage depth. Two systems working on different concepts have been developed. In one system a mechanism consisting of a ski or a trailing wheel indicates the position of the implement relative to the soil while the mechanism in turn activates the tractor's hydraulics to adjust and maintain a constant implement depth. A second project uses ultrasonics to obtain data on depth control, the effect of accuracy of depth control on crop yield and tractor energy consumption.
- A long term project will provide data to help to implement zero and minimum tillage practices in western Canada thereby contributing to a reduction in the amount of fuel required for crop production. A similar type of project in Quebec will define and determine physical properties of soils subjected to different tillage treatments. Some preliminary work undertaken by a contractor in previous years has shown that if the number of field equipment passes is reduced there are substantial increases in crop yield.

78-79 Funds: \$251,200

79-80 Funds: \$127,800

Subprogram P. Van Die, Engineering and Statistical Research Institute, Agriculture  
Director: Canada, Ottawa, Ontario, K1A 0C6. 613-995-9671.



Task: Conservation  
Program: Energy Conservation in the Food Supply System  
Subprogram: Processing

#### OBJECTIVE

To study and collect data on energy use in the processing, retailing and distribution practice in the food supply system. To determine what and how energy savings could be made.

#### WORK

This work has only recently started; proposed areas of study are:

- An overall review of the processing, distribution and retailing energy data base.
- Basic study and review of reduced energy processing techniques and the influence of substitution of these processes for conventional processing.
- Feasibility studies and development of new food processing techniques and systems that require less energy.
- Application of heat recovery techniques within the food processing sector.
- Comparative analysis of various processing technologies on which future processing and consumer purchasing can be based.

Work already started includes a review of information available on energy use and alternative possibilities in the food industry. It will include a review of United States work and on-site visits; detailed study of selected Canadian processors and assess the economic implications of the application of energy conservation technologies.

78-79 Funds: \$0

79-80 Funds: \$62,800

Subprogram Director: Dr. G. Timbers, Engineering and Statistical Research Institute, Agriculture Canada, Ottawa, Ontario, K1A 0C6. 613-995-9671.



Task: Conservation  
Program: Energy Conservation in the Food Supply System  
Subprogram: Conservation in Livestock Structures and Crop Drying

#### OBJECTIVE

To reduce livestock building heat requirements by using exhaust air heat recovery systems and more effective air distribution systems. To improve the energy efficiency of crop drying and curing processes.

#### WORK

Heat loss through ventilation can account for up to 80% of the losses in some farm buildings. An interlocked ventilation/heating system is being installed and will be evaluated for its ability to reduce fuel consumption for livestock buildings heating.

One project will be to design, construct and test in a hog barn a practical air to air heat exchanger that will be capable of operating continuously in an agricultural environment. Another project will be to install heat recovery equipment in conjunction with an optimized ventilation and control system in a broiler barn to compare the economics and operating characteristics of the unit to a conventional setup.

Tobacco curing is a large direct use of energy on the farm. A project to use recent field and research data to prepare an assessment of the most practical and cost-effective techniques for reducing energy use to flue cure tobacco is underway. Potential fuel savings of up to 30% are envisioned.

78-79 Funds: \$0

79-80 Funds: \$92,300

Subprogram Director: P. Van Die, Engineering & Statistical Research Institute, Agriculture Canada, Ottawa, Ontario, K1A 0C6. 613-995-9671.

Task: Conservation  
Program: Energy Conservation in the Food Supply System  
Subprogram: Greenhouses

#### OBJECTIVE

To develop retractable and fixed insulation systems to reduce heat losses in existing plastic and glass greenhouses without adversely affecting the greenhouse operation. The target is 90% heat loss reduction by 1983.

#### WORK

- Conduct concept engineering and development, technical and cost feasibility analysis of greenhouse insulation systems for Canadian conditions.
- Determine the feasibility of using transparent sealed plastic film containing heteropolar gas mixtures as an insulation layer inside existing greenhouses.
- Use of plastic covered tunnels in greenhouses to reduce heat losses and requirements.
- Evaluation of a folding accordion, roll-away blanket and sliding panels type of insulation for reducing heat losses in greenhouses.
- Design and development of a retractable film for reducing conductive and radiation heat losses in greenhouses.

78-79 Funds: \$50,000

79-80 Funds: \$174,000

Subprogram Director: H.A. Jackson, Energy & Statistical Research Institute, Agriculture Canada, Ottawa, Ontario, K1A 0C6. 613-995-9671.

1978-80

Task: Conservation  
Program: Thermal Wastes  
Subprogram: District Heating

#### OBJECTIVE

To find ways of utilizing waste thermal heat (particularly the heat from thermal power plants) for space and water heating.

#### WORK

Earlier work concentrated on the storage of heat since heat demand does not necessarily coincide with heat production because the latter is only a by-product. In particular, effort was concentrated on a new project on ground heat storage. This project is continuing at NRC and is a joint effort of the solar heating program and the district heating program as both applications require large low cost heat storage units.

Recently the emphasis has shifted to preparations for modern district heating systems so that R&D can be conducted on Canadian district heating conditions.

Particular areas being concentrated on include:

- instrumentation and control of heat flows
- insulation of distribution systems
- heat delivery variation

78-79 Funds: \$180,000

79-80 Funds: \$175,000

Subprogram Director: Dr. T. Ledwell, Conservation and Renewable Energy Branch, Energy, Mines and Resources, 580 Booth St., Ottawa, Ontario, K1A 0E4. 613-995-1801.

Task: Conservation  
Program: Thermal Wastes  
Subprogram: Energy Cascading

#### OBJECTIVE

The objective of this Subprogram is to reduce waste heat streams by using the most appropriate energy cascading technologies.

#### WORK

This Subprogram is at an early stage so most of the work is in identifying:

- existing and potential waste heat streams
- energy cascading technologies which would effectively reduce these streams and assessing the current status of these technologies in Canada and abroad
- the R&D requirements to enable the effective use of the energy cascading potential over the next 25 years.

Canada also participates in the IEA Common Study on Energy Cascading designed to assess promising technologies. Current focus is on a small organic Rankin cycle generator.

78-79 Funds: \$115,000

79-80 Funds: \$400,000

Subprogram Director: Dr. T. Ledwell, Conservation and Renewable Energy Branch, Energy, Mines and Resources, 580 Booth St., Ottawa, Ontario, K1A 0E4. 613-995-1801.

Task: Conservation  
Program: Thermal Wastes  
Subprogram: Cogeneration

#### OBJECTIVE

The first priority is to identify the Canadian potential for these technologies at current and future energy prices and analyse the reasons why this potential is not currently attained.

Secondly, to identify specific R&D and D projects that need to be supported by the federal government.

Thirdly, to support, with appropriate resources, the R&D requirements identified.

#### WORK

In 1978-79 studies were done on Canadian potential for cogeneration; completion of a boiler inventory; and production of a cogeneration manual. The studies on potential continue.

78-79 Funds: \$111,000

79-80 Funds: \$25,000

Subprogram Director: Dr. T. Ledwell, Conservation and Renewable Energy Branch, Energy, Mines and Resources, 580 Booth St., Ottawa, Ontario, K1A 0E4. 613-995-1801.



Task: Conservation  
Program: Thermal Wastes  
Subprogram: Low Grade Heat Utilization

#### OBJECTIVE

To supply some of the large demand for low grade energy, especially for space heating, from thermal wastes.

#### WORK

Work in this Subprogram is concentrated on identifying and supporting the R, D and D requirements to meet the objective. This work is closely linked with that in 1.4.2, 1.4.3 and 1.8.3 (heat pumps) and liaison established with the Buildings Program 1.1.

A specific project started in 1978-79 is the use of cooling tower water (at 32-50°C) at an oil refinery for greenhouse heating.

78-79 Funds: \$356,000

79-80 Funds: \$103,000

Subprogram Director: Dr. T. Ledwell, Conservation and Renewable Energy Branch, Energy, Mines and Resources, 580 Booth St., Ottawa, Ontario, K1A 0E4. 613-995-1801.

1978-80

Task: Conservation  
Program: Thermal Wastes  
Subprogram: Heat Exchange

#### OBJECTIVE

To assess present national and international efforts in this area in order to identify and support particular Canadian R&D requirements.

#### WORK

This program was started in 1979-80 and involves projects in high temperature industrial heat exchangers e.g. white water heat exchange, and air-to-air heat exchanges. The latter appears to have high potential, especially in air-tight houses.

78-79 Funds: \$0

79-80 Funds: \$100,000

Subprogram Director: Dr. T. Ledwell, Conservation and Renewable Energy Branch, Energy, Mines and Resources, 580 Booth St., Ottawa, Ontario, K1A 0E4. 613-995-1801.

Task: Conservation  
Program: Thermal Wastes  
Subprogram: Total Energy Systems

#### OBJECTIVE

To identify the potential advantages of decentralized combined systems for heat and electricity generation at local sites.

#### WORK

Work started in this Subprogram in 1979-80. The studies undertaken include:

- identifying the potential for total energy systems in commercial buildings by analysis of power/heat demand profiles
- identifying the institutional, economic and technical barriers to total energy systems

78-79 Funds: \$0

79-80 Funds: \$25,000

Subprogram S. Zaborowski, Conservation and Renewable Energy Branch, Energy, Mines  
Director: and Resources, 580 Booth St., Ottawa, Ontario, K1A 0E4. 613-995-1801.

Task: Conservation  
Program: Thermal Wastes  
Subprogram: Wood Waste Gasifier

## OBJECTIVE

To develop and demonstrate medium scale plants to provide gas from wood waste, municipal waste and blends of low grade coal and wood waste for use in the forest industry and in municipal power plant schemes.

## WORK

The phases of the work are:

- Preliminary Phase (1977-78) - To make the necessary modifications to the gasifier and ancillary equipment to achieve a 5-day continuous operation and to provide a package boiler capable of being fired with producer gas and/or oil.
- Phase I - To make modifications and additions to Reactor No. 1 to prove commercial operation by 3 to 4 week continuous operation and to utilize the gas produced to fire lumber drying kilns.
- Phase II - To fire Reactor 1 by alternate fuels such as municipal solid waste, animal waste, and a blend of low grade coal and wood waste.
- Phase III - To modify Reactor No. 1 to render the gas suitable for firing an internal combustion engine for power generation.

In 1978-79 this work became part of the Conservation and Renewable Energy Branch Special Demonstration program and so no further R&D funds were spent on it. Other work in this area is reported under Program 4.3, Biomass.

78-79 Funds: n.a.

79-80 Funds: n.a.

Subprogram Director: Dr. R. Thomson, Canada Centre for Mineral and Energy Technology,  
Department of Energy, Mines and Resources, 300 Lebreton Street, Ottawa,  
Ontario, K1A 0G1. 613-995-4044.

Task: Conservation  
Program: Municipal and Industrial Wastes  
Subprogram: Energy Recovery System Federal and Private Sector (Sheet 1 - Used Oils; Metals; and Rubber and Plastics)

## OBJECTIVE

To increase the recovery or savings of energy (and materials) from federal, provincial, municipal and industrial wastes.

## WORK

Three components are described on this sheet:

- The identification of quantities of used lubricating oils, their geographical distribution and disposal methods. An evaluation of existing methods of re-refining has been carried out in and proposals solicited from industry for improvements. The government is coordinating the efforts of the various sectors in Canada. A model guideline for used oil collection has been developed and generally accepted by the provinces and is a first step to the uniformity of regulation Canada wide. In 1978-79, work involved the demonstration of collection systems in federal facilities and the 'do-it-yourself' sector. Also initiated was field testing to demonstrate the acceptability of re-refined oils. The target is to have all used oil from federal facilities disposed of acceptably, and two million gallons of otherwise lost oil diverted to environmentally acceptable end uses. Relations have been established with the oil industry and the retail sector.
- As the metal scrap recovery industry has been well established for some time, efforts are being made towards ensuring that scrap from federal facilities is most efficiently recycled. An update of the ferrous scrap situation was conducted and a manual prepared on the improvement of collection, segregation and marketing of scrap from federal facilities. Ferrous recovery is well established so this work is finished. Inventories of silver recoverable from federal photographic operations were conducted in the Atlantic region, Quebec and Ottawa. Profitable projects were implemented.
- A study has shown potential for economic re-use of rubber from old tires. This was a shared cost project by Alberta, Saskatchewan, Manitoba and the Department of the Environment. A further study on incorporation of waste rubber in road asphaltic concrete was conducted in cooperation with Metro Toronto and industry. Results indicate doubling of paving life and improved performance for minimal increases in application costs. Recovery of plastics is also being studied.

78-79 Funds: \$218,000

79-80 Funds: \$120,000

Subprogram Director: Mr. D.S. Hay, Solid Waste Management Branch, Department of the Environment, 14th Floor, Place Vincent Massey, Ottawa, K1A 1C8.  
613-997-4334.



GOVERNMENT OF CANADA

1978-80

Task: Conservation

Program: Municipal and Industrial Wastes

Subprogram: Energy Recovery System Federal and Private Sector (Sheet 2 - Paper)

## OBJECTIVE

To increase the recovery or savings of energy (and material) from paper from federal, provincial, municipal and industrial wastes.

## WORK

The technical development of recovery of fine paper in federal establishments has made good progress. Earlier, at-source separation systems for high grades of waste paper were established in two specific offices in the federal buildings in Ottawa/Hull. First steps were also taken to expand the program to 10 other major buildings. Initial returns from this program approximate \$300,000 and energy savings were about  $7 \times 10^{10}$  Btu/annum. Some 19 buildings are involved now in Ottawa. Currently about 250 tons/month, netting the federal government over \$10,000/month, are being recovered. Another 24 buildings covering 35,000 employees will be added in 1979-80, bringing in another 175 tons/month.

The program has been extended to major regional centres and results will be available in 1979-80.

A secondary materials newsletter, entitled RECOUP, has been established and has received an excellent response from the paper industry.

A trial collection of telephone directories showed that this is also economic in present market conditions.

A preliminary study, so far not conclusive, on paper for animal bedding was conducted in cooperation with the Ontario Ministry of Energy.

Work continues on expanding these programs and on removing barriers to paper recycling, specifically over-specification and contaminants.

78-79 Funds: \$200,000

79-80 Funds: \$95,000

Subprogram Mr. D.S. Hay, Solid Waste Management Branch, Department of the Director:  
Environment, 14th Floor, Place Vincent Massey, Ottawa, K1A 1C8.  
613-997-4334.

Task: Conservation  
Program: Municipal and Industrial Wastes  
Subprogram: Energy Recovery System Federal and Private Sector (Sheet 3 - Municipal Wastes)

#### OBJECTIVE

To increase recovery of energy from municipal wastes.

#### WORK

A study on municipal wastes in communities over 100,000 population has been completed and provides a base for computing quantities and components of wastes available for recovery. Small scale incinerators in two hospitals were instrumented and performance analysed to make information available to organizations contemplating this waste management route. Of particular concern was the heat recovery aspect. Cooperative studies were conducted in Prince Edward Island to assess the feasibility of incineration with co-generation in small communities. This project (Charlottetown Q.E. Hospital) is on the point of going ahead with DOE, EM&R and DREE assistance.

A study to identify exactly why composting is generally unsuccessful in North America was initiated with completion in 1979-80.

Two projects on gas migration and generation from landfills have proven the practicality of collection and utilization of this gas in Canadian landfills.

Assistance was also given to the Ontario Waste Management Advisory Board to implement a uniform system of Municipal Accounting which for the first time should produce information on waste management comparable from one community to another.

The Source Separation Project at Canadian Forces Base Borden is complete, and the results are being analysed.

78-79 Funds: \$292,000

79-80 Funds: \$159,000

Subprogram Mr. D.S. Hay, Solid Waste Management Branch, Department of the Director:  
Environment, 14th Floor, Place Vincent Massey, Ottawa, K1A 1C8.  
613-997-4334.

Task: Conservation  
Program: Municipal and Industrial Wastes  
Subprogram: Energy Recovery System Federal and Private Sector (Sheet 4 - Industrial Wastes, Government Initiatives)

#### OBJECTIVE

To promote the recovery or saving of energy from industrial wastes.

#### WORK

- A study of the carbonated soft drink container in Canada has been completed. The beverage container work has been followed by examinations of procurement practices; a study of the effects of commodity on conservation has been initiated. Discussions are still ongoing with the soft drink and container industries.
- Based on earlier studies, the Canadian Industrial Waste Exchange has been established. Response has been good and has resulted in transfer totalling 45,000 tons equivalent to about \$2,000,000 in displaced materials. Ways of long term financing of the Exchange are being considered.
- A study of the pyrolysis of mine coal wastes concluded that this could provide economic, useable energy plus a slag suitable for direct spinning into rock-wool. However, in the light of current insulation industry competition, no sponsor has come forward to implement this idea.
- A study has been completed of a possible waste management charge on commodities as a deterrent to waste production. A long term study has been initiated to collect and document the benefits from conservation and recycling. The aim of this project is quantitative information and some trial measurements were conducted in 1979-80.

78-79 Funds: \$112,000

79-80 Funds: \$131,000

Subprogram Mr. D.S. Hay, Solid Waste Management Branch, Department of the Director:  
Environment, 14th Floor, Place Vincent Massey, Ottawa, K1A 1C8.  
613-997-4334.

Task: Conservation

Program: Municipal and Industrial Wastes

Subprogram: Cost Shared Development and Demonstration of Resources and Energy  
Conservation Technology

#### OBJECTIVE

To encourage industry to develop and adopt resources and energy conservation technologies.

#### WORK

Three proposals accepted are:

- Incineration and cogeneration at a hospital.
- Source separated material: a collection vehicle.
- Glass beneficiation.

78-79 Funds: \$298,000

79-80 Funds: \$555,000

Subprogram Mr. D.S. Hay, Solid Waste Management Branch Department of the Director:  
Environment, 14th Floor, Place Vincent Massey, Ottawa, K1A 1C8.  
613-997-4334.



Task: Conservation  
Program: Oil and Gas Combustion  
Subprogram: Domestic Oil Heating Systems

## OBJECTIVE

To develop retrofit packages to increase energy efficiency of domestic oil burners, to develop matched burner/furnace combinations and to develop performance standards.

## WORK

In cooperation with CREB, CCA, CSA and the major oil companies, CANMET's program in oil space heating will make available to the consumer, certified retrofit equipment of domestic space heating equipment. The major oil heating companies have initiated personnel training programs to ensure a capability for installation and servicing of such retrofitted equipment. In conjunction with the development of national and regional energy conservation strategies, new burner-furnace combinations, developed under contract, will also be certified for domestic use. A secondary but essential part of this program will be to ensure compatibility of such retrofitted and new equipment with degrading quality (increased aromatic content) of No. 2 heating oil, as may be obtained from refined Athabasca bitumen and from coal liquefaction.

In 1978-79, residential heating data reduction was completed. Evaluation of a burner (jointly with industry) has been completed indicating satisfactory performance but a tendency to coke after prolonged cycling. Performance of retrofit equipment (retention head, solenoid switch and fan) has been evaluated for four burners. The contracts for development of low Btu and of dual firing rate oil burners is on schedule. Three proprietary fuel oil additives have been evaluated.

Work in 1979-80 included efforts towards implementation of a national oil space heating retrofit program in cooperation with CREB and the oil space heating installation and servicing industry and identification of a strategy concerning new burner/furnace combinations. About 10 retrofitted burners are being submitted to CSA for certification. A burner servicing manual has been produced in cooperation with the oil companies and provinces to improve quality of furnace servicing with emphasis on implications to unit efficiency. Potential effects of promising additives to No. 2 heating oil are being evaluated.

78-79 Funds: \$232,000

79-80 Funds: \$275,000

Subprogram Director: Dr. R. Thomson, Canada Centre for Minerals and Energy Technology,  
Department of Energy, Mines and Resources, 555 Booth St., Ottawa, Ont.,  
K1A 0G1. 613-995-4044.



Task: Conservation  
Program: Oil and Gas Combustion  
Subprogram: Domestic Gas Heating Systems

## OBJECTIVE

To develop retrofit packages to increase energy efficiency of domestic gas burners to develop matched burner/furnace combinations and to develop performance standards.

## WORK

CANMET, in cooperation with CREB, the Consumers Gas Association and CGRI embarked on a program of increasing efficiency of gas space heating systems. This effort is parallel to the oil space heating program (1.6.1) in that the approach will be towards development of devices capable of being retrofitted to existing units and of new, more efficient burner/furnace combinations. While the major efficiency increase can be gained by recovering hydrogen losses, for example by retrofitting a condensing flue system, other potential benefits can accrue through use of electronic ignition, power burners, chimney dampers and add-on heat exchangers.

In 1978-79 there was no in-house effort directed towards this area.

In 1979-80 the work is to explore, by contract, the technical feasibility of using a condensing flue system as both a retrofit device and in conjunction with a new power burner/furnace combination.

78-79 Funds: \$0

79-80 Funds: \$31,000

Subprogram Director: Dr. R. Thomson, Canada Centre for Minerals and Energy Technology,  
Department of Energy, Mines and Resources, 555 Booth St., Ottawa, Ont.,  
K1A 0G1. 613-995-4044.

Task: Conservation  
Program: Oil and Gas Combustion  
Subprogram: Industrial Burners

## OBJECTIVE

To develop multi-fuel industrial burners and to examine the use of modulating and cycling burners.

## WORK

Although industrial oil burners generally are of higher efficiency than those used for space heating, considerable conservation benefits in terms of barrels of oil can be gained by small improvements in efficiency. There is a long term need to develop burners capable of sustaining a stable flame while fired by low Btu gas in the 80-150 Btu/MCF range. Technology development is now in place to demonstrate the technical feasibility of producing low Btu gas from municipal waste, renewables and coal rejects. Development of such a burner will permit displacement of No. 6 oil and/or natural gas in meeting in-plant steam loads in the pulp and paper industry, at coal preparation plants, and associated with municipal and wood waste disposal.

From 1978-79, a joint CANMET/FERA study on atomization variables affecting the combustion of No. 6 heating oil has produced a literature survey of the state-of-the-art, defined the requirements for R&D, and defined the roles of the member representatives.

Work 1979-80 consists of:

- A CANMET/FERA cooperative program conducted in-house, to assess the important variables, amongst steam/oil ratio, steam pressures and temperatures, oil pressure and temperature etc., in terms of energy requirements and costs and to identify the optimum combination of variables.
- A scale up of the design of two types of burners capable of operating with clean or dirty gas in the range 100,000 to 150,000 Btu/hr, to test their performance under a variety of conditions and to design, build and operate a full sized industrial burner having inputs of between 500,000 and 1,000,000 Btu/hr.

78-79 Funds: \$3,000

79-80 Funds: \$121,000

Subprogram Director: Dr. R. Thomson, Canada Centre for Minerals and Energy Technology,  
Department of Energy, Mines and Resources, 555 Booth St., Ottawa, Ont.,  
K1A 0G1. 613-995-4044.

Task: Conservation  
Program: Oil and Gas Combustion  
Subprogram: Multi-fuel Industrial Turbines

#### OBJECTIVE

To develop multi-fuel combustion systems for industrial gas turbines.

#### WORK

A joint NRC/Industry program has been underway to develop and test turbines capable of operating at high combustion and system efficiencies on both diesel and natural gas fuel. Also characterized are the emission levels for nitrogen oxides carbon monoxide, unburned hydrocarbons and smoke. Such turbines, in the size range 15-40,000 h.p., would have use, for example, in gas fired pumping or electrical generation.

In 1978-79, testing of a 36,000 h.p. turbine took place and will likely continue until 1981 while successful demonstration of another large gas turbine is nominally complete. Some chamber performance problems with the latter relating to hot spots have been solved while investigation of a starting problem is being undertaken. Development and testing of an 18,000 h.p. turbine with heat exchanger air preheat will be initiated.

78-79 Funds: \$150,000

79-80 Funds: \$150,000

Subprogram R.A. Tyler, Division of Mechanical Engineering, National Research  
Director: Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-2442.

Task: Conservation  
Program: Industrial Processes  
Subprogram: Industrial Energy R&D Program

#### OBJECTIVE

To promote industrial research and development that will contribute to more efficient future uses of process energy by industry.

#### WORK

The projects receiving assistance under this Program, are proposed by Canadian companies, and the experimental work and eventual exploitation of the results are performed by the applicants. Assistance normally amounts to 50 percent of the estimated cost of an approved project. The applications received are appraised against standard selection criteria that are concerned both with the quality of the project and the capabilities of the applicant. Implementation of the Program and appraisal of the applications are primarily the responsibility of the Industrial Branches of the Department of Industry, Trade and Commerce. The final recommendation on the approval or rejection of a project is made by an interdepartmental advisory committee which also ensures coordination with energy conservation policies and other existing support programs.

The development projects approved since the introduction of the Program involve:

- A computer assisted model of kraft pulp mills to analyse energy savings measures dealing with mill equipment and operating practices.
- Development of heat pipes for waste heat recovery.
- Steel industry soaking pit construction material.
- Semi-dry cement kiln process.
- Utilization of evaporated paint solvents as drying oven fuel.
- Power consumption by electroplating processes.
- Addition of waste combustible material to clay bricks before firing.
- Balancing of paper machine operations to allow recovery of waste heat.
- A novel boghouse to eliminate the need for afterburner in the production of non-ferrous casting alloys.
- A system for continuous sampling, filtering, drying and analysing of high temperature flue gases.
- Use of coal fine rejects to replace other fuels in metallurgical coal dryer.

78-79 Funds: \$640,000

79-80 Funds: \$1,500,000

Subprogram L. Hart, Technology Branch, Department of Industry, Trade &  
Director: Commerce, 235 Queen Street, Ottawa, Ontario, K1A 0H5. 613-593-7861.



Task: Conservation  
Program: Energy Conversion, Storage and Hydrogen Systems  
Subprogram: Energy Conversion and Storage (Sheet 1 - Flywheels; Storage Systems with Thermal Output)

#### OBJECTIVE

To evaluate the potential for flywheel energy storage systems. To devise means to overcome time and temperature mismatches between heat source and utilization.

#### WORK

Two components are described on this sheet:

- The date, the work on flywheels has consisted of studies. The most probable application of this technology will be hybrid flywheel high-energy systems for energy conservation in road vehicles. The objectives are to design, fabricate and test composite rotors. This work is progressing in cooperation with TC, EMR and DND. An extensive literature compilation has been completed; a contract has been let to determine the strategy for the rotor design and testing. There is no reason at this state to dispute claims relating to the energy savings which can result from the use of short term storage in road vehicles.
- Heat storage offers great potential for reducing capital equipment costs and also saving premium fuels. A large proportion of energy is consumed as heat either in space heating or as industrial process heat. Frequently the supply and demand for this heat are mismatched either in a time sense or in a temperature sense. Projects in progress include: (1) low temperature heat transfer in heat-of-fusion storage systems for solar applications. A number of difficulties have been overcome, and very acceptable heat delivery rates have been achieved at all states of discharge. Novel salt compositions have been tested and constant temperature delivery throughout discharge has almost been achieved. (2) investigation of heat storage and transmission using reversible chemical systems. The program will examine the use of such chemical systems both in primary energy conversion and transmission as well as in long term storage particularly associated with renewables. In addition the ever present problem of low grade waste heat utilisation will be considered as a potential input for chemical systems either for storage, transmission or upgrading. (3) the problems associated with using salt heats of fusion for high temperature storage and the development of a computer model for such a system. Instrumented test cells are being used to test and optimise designs. Close liaison will be maintained with the utilities and all possible applications will be evaluated. At the moment, storage water heating, space heating and electric vehicle comfort heating are possibilities.

78-79 Funds: \$90,000

79-80 Funds: \$380,000

Subprogram Director: Dr. J.B. Taylor, Division of Chemistry, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-2506.



Task: Conservation

Program: Energy Conversion, Storage and Hydrogen Systems

Subprogram: Energy Conversion and Storage (Sheet 2 - High Temperature Materials; Hydrogen and Structural Materials)

#### OBJECTIVE

To ensure availability of materials suitable for advances in energy storage and conversion.

#### WORK

The use of a Scanning Auger Microprobe has provided new insight into the processes of deterioration of materials. Using the instrument, work has started on

(i) the composition and growth of oxide films on Fe-Cr alloys, and methods of producing a more protective high temperature oxide film. Work progresses on the composition and growth of oxide and sulphide films on Fe-Cr alloys. Different prior oxides have been produced on Fe-Cr alloys and their protective quality determined from kinetic studies at temperatures of 600°C. The Scanning Auger Microprobe is being used to determine the Fe, Cr and O content of the prior oxide film and the changes in composition which occur during high-temperature oxidation.

(ii) co-operative research between NRC and CANMET on alloy embrittlement.

To complement the oxidation studies, a contract has been let to study the influence of S and C-containing atmospheres on protective oxide formation on Fe-Cr base alloys.

Embrittled materials (temper or hydrogen) will be fractured in-situ in the Scanning Auger Microprobe, and the segregation of alloying and residual elements along grain boundaries will be determined in order to understand the mechanisms of failure.

78-79 Funds: \$445,000

79-80 Funds: \$250,000

Subprogram Director: Dr. M.J. Graham, Division of Chemistry, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-2518.

1978-80

Task: Conservation

Program: Energy Conversion, Storage and Hydrogen Systems

Subprogram: Energy Conversion and Storage (Sheet 3 - Magneto Hydrodynamics)

## OBJECTIVE

To establish the electrochemical principles and attainable efficiencies for the  $H_2/O_2$  magneto hydrodynamic (MHD) systems.

## WORK

The CANHO storage and conversion systems in which  $H_2$  is generated (e.g. from nuclear or tidal systems at times of low demand) and is burned in the MHD system to supply power at times of high demand shows promise as a load-levelling or load-following scheme. Other applications for systems of this kind include pulsed-power or high-specific-power-systems.

Elements of an experimental MHD system are being addressed. A 140 kW thermal  $H_2/O_2$  MHD system, consisting of a combustor, a transpiration-cooled ceramic test-duct, an electrode test module, and a diffuser-condenser is to be built and operated. A 2 Tesla superconducting magnet is to be wound and operated. Preliminary experimental studies involving thermal measurement to demonstrate and evaluate transpiration cooling of the MHD channel, and plasma characterization both with and without magnetization. It is intended both to extend this work to a 1 to 2 megawatt thermal system operating at 1 to 2 atmospheres and to elaborate the plasma measurements on the existing 140 kW thermal system. New ceramic materials are to be developed and tested, and the best of these are to be used to construct the MHD channel. Plasma conductivities appropriate to efficient MHD operation are to be demonstrated. The plasma will be studied under power producing conditions using a 2 Tesla superconducting magnet. The conceptual design of the 5 megawatt thermal CANHO system is being advanced to the more detailed engineering design and costing stages and the contractor is to produce short awareness reports on the status of development of MHD systems world-wide.

A contract has resulted in the identification, characterization and delivery of samples of a series of doped perovskites which show promise as highly conductive, yet protective coatings for current collectors in MHD channels containing hot hydrogen/oxygen plasma. It was proposed to extend this work by searching for compositions with better chemical stability in hydrogen/oxygen plasmas in the temperature range 1600-1800°C.

78-79 Funds: \$135,000

79-80 Funds: \$150,000

Subprogram Director: Dr. E.J. Casey, Defence Research Establishment Ottawa, Department of National Defence, 101 Colonel By Drive, Ottawa, Ontario. 613-596-9228.

1978-80

Task: Conservation

Program: Energy Conversion, Storage and Hydrogen Systems

Subprogram: Energy Conversion and Storage (Sheet 4 - Advanced Batteries; Directed Electrochemical Studies)

#### OBJECTIVE

To develop advanced batteries which might in the future be suitable for load leveling and vehicle applications and to determine the capabilities of the Canadian battery industry to perform R&D in this area.

Directed electrochemical studies are aimed at the development of components on complete systems which will reduce electrical consumption or improve overall efficiency in other ways.

#### WORK

- With respect to advanced batteries, an investigation of the  $\text{LiAl} - \text{FeS}_x$  battery systems was initiated. Charge-discharge characteristics of the  $\text{FeS}_2$  electrode and a number of intercalation-type cathodes ( $\text{Mo}_2$  and  $\text{TiS}_2$ ) were studied. In addition, a pre-prototype  $\text{LiAl-FeS}$  cell was built. These investigations continue with an eighteen-cell battery to be delivered for evaluation.
- Investigations of alternative cathodic, anodic and electrolyte materials continue. The potential of these systems is being evaluated, for load-levelling, electric vehicles and specialized high-rate applications. This task is intended as an awareness and semi-development program which will enable the federal agencies better to advise Canadian industrial and commercial organizations. Rechargeable lithium batteries which operate at ambient temperatures remain highly desirable but are still unobtainable. Two studies are underway on the rechargeability of lithium with the objectives: (1) to investigate the reversibility of lithium and lithium alloys in a number of nonaqueous electrolytes of fundamental and practical interest; (2) to use ultra pure procedures in the preparation of experimental cells which can be used as a base line for investigation of the effect of impurities on rechargeability.
- With respect to directed electrochemical studies, a study had been made of methods for reducing anode overvoltage in electrowinning cells. The decrease in anode potential can be translated into a possible power saving in industrial copper winning practice, of about 1MWh/ton of copper produced. Long term testing is continuing.
- The design and assessment of a device for electrochemical storage of photon energy was undertaken under contract. Photoelectrode and storage electrodes were prepared and a complete cell delivered for evaluations. Electrode performance optimization and cycling capability is being investigated.
- The evaluation of the feasibility of a dialytic battery concept for storage of huge quantities of electrical energy in saline concentration-cells, is being done.

78-79 Funds: \$284,000

79-80 Funds: \$525,000

Subprogram Dr. E.J. Casey, Defence Research Establishment Ottawa, Department of  
Director: National Defence, 101 Colonel By Drive, Ottawa, Ontario. 613-596-9228.

Task: Conservation  
Program: Energy Conversion, Storage and Hydrogen Systems  
Subprogram: Hydrogen Systems (Sheet 1 - Hydrogen Storage; Fuel Cells; Alternative Technologies for Hydrogen Production)

## OBJECTIVE

To study the storage of hydrogen by its reaction with metallic alloy systems to produce solid metal hydrides. To identify possible directions for a Canadian program in fuel cells. To examine alternative technologies for hydrogen production.

## WORK

Three components of the work are described on this sheet:

- The potential for storage as metal hydrides being evaluated, critical parameters will be determined and the data will be applied to develop an optimized system. A detailed study will be made of the hydriding process with particular reference to practical systems. Initially, the diagnostic tool will be a heat flow-type calorimeter with which thermochemical data will be obtained. The facility will be unique in Canada and the particular approach has not been applied previously to the alloy metal hydrides. Further efforts will be made to expand the diagnostic capability by using high pressure reaction cells on an X-ray diffractometer to obtain structural data.
- Earlier, a collection and evaluation was taken of alternative hydrogen methods (other than chemical reaction with fossil fuels and electrolysis). Work on the thermochemical production generation of hydrogen includes studies on existing cycles and novel cycles. A five-year program is envisaged and a primary objective will be a detailed evaluation of the future prospects for the production of hydrogen in Canada by thermochemical methods.
- Photo-assisted electrolysis of water in the visible region using semi-conductor electrodes, provides a direct method of using sunlight for hydrogen production. A stable and photo-sensitive electrode with a good quantum efficiency is needed for this purpose. CANMET will investigate redox reactions on transition metal sulphides, particularly of the layer type, and their photo-electrochemical and spectral response in relation to their band structure.
- An analysis of Canadian opportunities for research/development of fuel cells as well as commercial exploitation is underway. The following applications are being considered: public utility power generation; industrial power generation; generation of electricity for small, isolated communities; the use of fuel cells in transportation; and fuel cells as small, portable sources of power.

78-79 Funds: \$350,000

79-80 Funds: \$226,000

Subprogram J.J. Murray, Division of Chemistry, National Research Council, Montreal  
Director: Road, Ottawa, Ontario K1A 0R6. 613-993-2506.



1978-80

Task: Conservation  
Program: Energy Conversion, Storage and Hydrogen Systems  
Subprogram: Hydrogen Systems (Sheet 2 - International Activities: Hydrogen Market Study; Advanced Electrolysis)

## OBJECTIVE

To assess the potential markets for energy and non-energy uses of hydrogen in Canada and provide cost comparison of electrolytic production with other methods. To develop materials and systems necessary for the construction of advanced alkaline electrolyzers and of high temperature water vapour electrolyzers.

## WORK

- The market study is being conducted in support of Canada's participation in Annex III of the International Energy Agency Implementing Agreement for a Program of Research and Development on the Production of Hydrogen from Water. The assessment work is based upon an analytical framework which will consider all major elements of existing and projected energy systems in Canada for the periods 1985 to 2000 and 2000 to 2025. A coordinating committee, the Canadian Advisory Committee on Hydrogen has been established with representatives from federal and provincial governments, industry and universities.
- Advanced electrolysis work is being conducted in support of Canada's participation in Annex IV and Annex V of the IEA Implementing Agreement. Annex IV includes the following work: 1) selection and evaluation of separator materials for high temperature operation 100-200°C; 2) long term testing of promising separator materials in large-scale equipment; 3) selection and evaluation of electrocatalysts for the hydrogen and oxygen electrode reactions; 4) long term testing of promising electrocatalysts in commercial equipment; and R&D on improved solid polymer electrolyte membranes.

Under Annex V the work involves the development and fabrication of ceramic electrolytes for oxygen ion or hydrogen ion transport.

Some of these tasks relate to the development of materials which, although pertinent to the electrolyser program, are not specifically confined to this application. Thus the electrocatalysts can have value in fuel cells; the solid polymer electrolytes in the chlor-alkali industry, batteries and fuel cells; the ceramic electrolytes in batteries.

Most of the work is contracted; NRC is starting an in-house membrane program.

78-79 Funds: \$50,000

79-80 Funds: \$325,000

Subprogram J.B. Taylor, Division of Chemistry, National Research Council, Montreal  
Director: Road, Ottawa, Ontario K1A 0R6. 613-993-2506.



1978-80

Task: Conservation  
Program: Energy Conversion, Storage and Hydrogen Systems  
Subprogram: Heat Pumps

## OBJECTIVE

To develop better ways of utilizing electricity for heating buildings and sanitary water.

## WORK

A heat pump is a potentially useful device for converting electricity into heat as it can deliver about twice as much useful heat per unit of electricity used as an ordinary electrical resistance heater.

A contract was awarded to a Canadian company to develop a hybrid furnace/electric heat pump that would be suitable for use in Canadian houses. The furnace component would provide the supplementary heat when the heat pump output was not sufficient to meet the house heating load on its own. Furnaces of this type would be logical replacements for oil furnaces in existing buildings. In this way electricity could replace about two thirds of the fuel that is now being burned without causing any substantial increase in the peak demand for electricity and, thus, would help to increase the load factor for the electrical utilities. A prototype unit is being subject to "field trials" during the heating season.

The in-house work has concentrated on developing an improved procedure for calculating the amount of energy that would be required to operate a heat pump in a house for a full heating season. A heat pump system has been installed in a test house and is being monitored to check the accuracy of the new calculation procedure.

The International Energy Agency has originated a multinational cooperative project to investigate the feasibility of using an internal combustion engine as the drive for the heat pump. The initial phase of this project involves assessing the possible markets for this type of heating equipment. If this looks promising this will be followed by R&D to develop equipment of this type in one or more of the participating countries. Canada is participating in this project.

Because of the importance of heat pumps and the relationship to other Programs, this work will in future be located in a separate Program.

78-79 Funds: \$181,000

79-80 Funds: \$310,000

Subprogram R.L.D. Cane, Division of Building Research, National Research Council,  
Director: Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-1421.

Task: Conservation  
Program: Urban Form and Operations  
Subprogram: Urban Form

#### OBJECTIVE

To ensure that energy and urban managers in the public and private sectors are more aware of the potential energy savings in urban planning.

#### WORK

In its report 'Energy Conservation in Canada', the federal government recognized that significant energy savings could be realized through energy sensitive community planning. Considerably more research has been undertaken in Canada on the relationship between energy consumption and individual building characteristics than those at the community scale. Work is being undertaken to identify the opportunities for reducing energy inefficiencies in cities through modifications to urban form and design for new and existing communities.

#### Projects are:

- Urban Form and Energy studies to compare alternative urban form characteristics and their effects upon energy consumption and to assess the prospects and opportunities in Canadian urban municipalities to pursue energy conserving measures through changes to urban form.
- Energy Efficient Physical Design to determine the extent to which climatically sensitive physical design characteristics at various community scales effect energy consumption, and to identify potential energy savings through introducing these design principles into new community development.

78-79 Funds: \$100,000

79-80 Funds: \$100,000

Subprogram Director: Mr. P. Favot, Research and Development Division, Canada Mortgage and Housing Corporation, Montreal Road, Ottawa, Ontario, K1A 0P7.  
613-746-4611.

1978-80

Task: Conservation  
Program: Urban Form and Operations  
Subprogram: Urban Operations

#### OBJECTIVE

To make society more aware of, and responsive to, energy concerns in urban operations.

#### WORK

The federal government recognizes that a prerequisite for achieving an effective national energy conservation strategy is through changing attitudes and preferences of individuals and institutions. Significant amounts of energy are currently consumed in the operations of municipal services. Potential energy savings can be realized through introducing a range of energy conservation techniques directed at the various activities. As a first stage in developing an energy conservation program in municipal operations, work has begun to assemble information for use by municipal planning officials on energy consumed in the delivery of municipal services. The information provided will identify the more energy intensive municipal services for which appropriate energy conservation measures can be developed.

78-79 Funds: \$50,000

79-80 Funds: \$50,000

Subprogram Director: Mr. P. Favot, Research and Development Division, Canada Mortgage and Housing Corporation, Montreal Road, Ottawa, Ontario, K1A 0P7.  
613-746-4611.

Task: Conservation  
Program: Consumer Products and Lifestyles  
Subprogram: Problem Identification and Analysis

#### OBJECTIVE

To obtain from studies, baseline or foundation data on certain consumer energy conservation issues.

#### WORK

The work in this program includes the following studies:

- a taxonomy of consumer energy use lifestyles and their receptivity to alternative conservation policies
- analysis of the energy situation attitudes survey
- consumer products and lifestyles research seminars
- consumer energy conservation bibliography
- conservation potential within consumers leisure and recreational activities
- consumer products and lifestyles potential energy savings matrix
- overview paper on life cycle costing
- overview topic paper on the potential for energy conservation in packaging of consumer products

78-79 Funds: \$126,000

79-80 Funds: \$55,000

Subprogram Mr. L. McCabe Consumer Research Branch, Consumer and Corporate Affairs,  
Director: 17th Floor, Place du Portage, Hull, Quebec, K1A 0C9. 613-997-1741.

Task: Conservation  
Program: Consumer Products and Lifestyles  
Subprogram: Policy Definition, Selection and Development

#### OBJECTIVE

With the aid of data collected in 1.10.1, to define, examine, select and develop policies to modify the patterns of energy use at the consumer level.

#### WORK

The work plan for this subprogram includes studies in the following areas:

- decision making in the purchase of heating equipment and major appliances for new housing and rental accomodations
- consumer products packaging conservation: an investigation into the amount of packaging consumers are willing to forego
- point-of-purchase energy information disclosure and consumer choice behaviour
- overview topic paper on mass media energy conservation communications policy
- microeconomic energy conservation policy analysis
- overview topic paper on energy use feedback and consumer behaviour
- an evaluation of selected consumer energy conservation policies from a government, business and consumer perspective

Planned extensions of some of the topics in 1.10.1 are:

- extension and application of the life cycle cost concept
- education programs for the promotion of energy conservation: an examination of the impact on student and household behaviour

78-79 Funds: \$118,000

79-80 Funds: \$95,000

Subprogram Director: Mr. L. McCabe Consumer Research Branch, Consumer and Corporate Affairs,  
17th Floor, Place du Portage, Hull, Quebec, K1A 0C9. 613-997-1741.



Task: Conservation  
Program: Consumer Products and Lifestyles  
Subprogram: Program Implementation, Evaluation and Modification

OBJECTIVE

To evaluate and modify existing programs and studies.

WORK

Work to date in this program includes:

- ENERGUIDE evaluation
- community energy conservation through citizen participation
- energy cost indicator pilot project

78-79 Funds: \$10,000

79-80 Funds: \$115,000

Subprogram Director: Mr. L. McCabe Consumer Research Branch, Consumer and Corporate Affairs,  
17th Floor, Place du Portage, Hull, Quebec, K1A 0C9. 613-997-1741.

TASK 2 .  
FOSSIL FUELS

## Introduction To TASK 2: FOSSIL FUELS

Canada is highly dependent on fossil fuels. Petroleum, natural gas and coal account for about two thirds of the primary energy. Nearly all of Canada's fossil fuel production is from conventional sources: oil and natural gas from conventional pools in southern Canada; coal obtained by conventional mining, transported by ship and rail, and used in thermal-electric generating stations. Exceptions, such as production from the oil sands, are few and are only beginning to play a significant role.

Yet Canada has vast quantities of non-conventional fossil fuels. Some, such as the oil sands and heavy oil deposits, are reasonably well defined. Others, such as Arctic and East Coast oil and gas, are speculative although the evidence to date is encouraging. Even large conventional sources, such as the western coal seams, have a future that may be dependent upon emerging technology such as liquefaction, fluidized bed combustion or in situ gasification. These non-conventional coal utilization technologies will permit the increased use of Canada's coals in more energy efficient and environmentally acceptable ways and as substitutes for conventional liquid hydrocarbons.

The imperative of this task, therefore, is to develop the technology needed to exploit non-conventional fossil fuel energy sources, whether it be for resource determination, extraction, processing or utilization. Transportation of energy commodities is covered under Program 5.1.

The Task Coordinator is:

Dr. D.A. Reeve  
Director, Energy Resource Program  
Canada Centre for Mineral and Energy Technology  
Department of Energy, Mines and Resources  
555 Booth Street  
Ottawa, Ontario, K1A 0G1  
613-995-4060

### 2.0 Conventional Oil and Gas

The 1976-77 edition of this Inventory listed four Subprograms; they covered techniques in off-shore and permafrost areas and environmental impact. The Program has been redefined and is directed toward studies of tight gas resources (2.02) and natural gas hydrates (2.03).

The Program Convenor is:

Dr. J.E. Brindle  
Institute for Sedimentary and Petroleum Geology  
Department of Energy, Mines and Resources  
3303-33rd Street N.W.  
Calgary, Alberta, T2L 2A7  
403-284-0110

## 2.1 Oil Sands and Heavy Oils

In the western Canadian provinces of Alberta and Saskatchewan lie immense reserves of bitumen mixed with sand, clay, minerals and water (the oil sands) and molasses-like oil held in porous rock (heavy oils). Modest but expensive amounts of crude oil are now being produced from both resources; expansion is planned. Considerable research on both is being carried out by industry and the provincial governments (see bibliography re Alberta Oil Sands Information Centre). The federal government also conducts and finances some research mainly on resource measurement and assessment (2.1.1), the technology for exploitation and recovery (2.1.2), and improved liquid yields (2.1.3). The major activity is the commercialization of the CANMET hydrocracking technologies which can increase liquid yields.

The Program Convenor is:

Dr. H. Sawatzky  
Canada Centre for Mineral and Energy Technology  
Department of Energy, Mines and Resources  
555 Booth Street  
Ottawa, Ontario, K1A 0G1  
613-995-4053

## 2.2 Coal Gasification and Liquefaction

Canada's large coal reserves and long transportation distances make attractive the prospects of coal conversion close to the mine mouth. Several techniques are under study with the emphasis roughly balanced between gasification and liquefaction.

Work is done in-house (2.2.4 and 2.2.5) to develop bench scale test facilities to determine the gasification reaction characteristics of Canada's coals and bitumen and the liquefaction properties of Canadian coals. Through contract programs (2.2.6 and 2.2.7) the development, understanding and demonstration of gasification and liquefaction technologies is encouraged in Universities and industry. There is some research dealing with the material problems in the various aspects of coal conversion (2.2.7).

The Program Convenor is:

Dr. H. Sawatzky  
Canada Centre for Mineral and Energy Technology  
Department of Energy, Mines and Resources  
555 Booth Street  
Ottawa, Ontario, K1A 0G1  
613-995-4053

## 2.3 Coal Supply

Coal supply for direct combustion as well as conversion is of increasing importance as the availability of low-priced oil and gas drops. Canada has large coal reserves in the western provinces and to a lesser extent in the maritime provinces; production is expected to rise dramatically in the next two decades. As technology must be available in advance, the

federal government undertakes R&D on resource and reserve assessment (2.3.0, 2.3.1, 2.3.2), mining technology (2.3.3), preparation (2.3.4) carbonization (2.3.5) and materials for coal production (2.3.7).

Canada's work with the IEA is described in this Program (2.3.6) and the areas covered are: Economics, Resources and Reserves, Information Service and Mining Technology.

The Program Convenor is:

Mr. R. Sage  
Canada Centre for Mineral and Energy Technology  
555 Booth Street  
Ottawa, Ontario, K1A 0G1  
613-995-4295

## 2.4 Coal Combustion

This Program is promoting the use of coal in two ways: by demonstrating the technical and economic benefits of burning coal in place of oil and gas in conventional combustion technologies (2.4.1); and by coordinating the introduction of new, high-risk, high capital cost combustion technologies which require government financing (2.4.2, 2.4.3 and 2.4.4).

The Program Convenor is:

Dr. R. Thomson  
Canada Centre for Mineral and Energy Technology  
Department of Energy Mines and Resources  
555 Booth Street  
Ottawa, Ontario, K1A 0G1  
613-995-4044



Task: Fossil Fuels  
Program: Conventional Oil and Gas  
Subprogram: Hydrocarbons from Low-Grade Reservoirs (Tight Gas)

## OBJECTIVE

The objective is to determine the quantities of gas that may be recoverable from low quality, relatively low permeable sandstone reservoirs in the Deep Basin of western Canada.

## WORK

This work began in 1978-79.

The project is being implemented by conducting geological studies and research towards a comprehensive knowledge of in-place unconventional and conventional gas, the probable quantities recoverable by various recovery techniques, and costs related to exploration and production into Canada's gas supply.

Evaluation is proposed to be done in three stages:

- stage one will include delineation of areas favourable for gas occurrence and will include an estimate of in-place resources by different zones.
- stage two will focus on the recoverable fraction and related costs.
- stage three might involve participation in the technology of extraction.

78-79 Funds: \$120,000

79-80 Funds: \$89,000

Subprogram Dr. D.F. Stott, Institute for Sedimentary and Petroleum Geology,  
Director: Department of Energy, Mines and Resources, 3303-33rd St. N.W., Calgary,  
Alberta, T2L 2A7. 403-284-0110

Task: Fossil Fuels  
Program: Conventional Oil and Gas  
Subprogram: Natural Gas Hydrates

#### OBJECTIVE

To precisely determine the hydrate type of the natural gas hydrate deposits in the Canadian permafrost regions.

#### WORK

The quantity of natural gas present in the form of hydrates (clathrate ices) in the Mackenzie Delta has been estimated as 3 trillion cubic feet at Standard temperature and pressure. The NRC has done some studies on the physical and chemical properties of the gas hydrates. The plan now is to study intact cores using the proton nuclear magnetic resonance method for non-destructive identification of the presence of gas hydrate.

78-79 Funds: \$40,000

79-80 Funds: \$47,000

Subprogram Dr. D.M. Wiles, Chemistry Division, National Research Council, Montreal  
Director: Road, Ottawa, Ontario, K1A 0R6. (613) 993-2330

Task: Fossil Fuels  
Program: Oil Sands and Heavy Oils  
Subprogram: Oil Sands and Heavy Oil Resources (Sheet 1 - Exploration)

## OBJECTIVE

To estimate the extent of recoverable resources from Canada's heavy oils and oil sands.

## WORK

A study has been initiated to determine the extent of in-place resources of heavy oils and oil sands as well as the recoverable portion of those resources; and to make projections of the impact of these resources on Canada's oil supply. The study involves extensive geological engineering cost and rate analysis of those deposits known or assumed to exist. This includes petrophysical studies, log analysis, construction of recovery processes and knowledge of costs of extraction and processing. The majority of the work is being contracted out.

In 1977-78, research on the heavy oil of the Lloydminster region was given priority with references being compiled on heavy oil occurrences, and research on the geology of the Mannville Group initiated. Some progress was made on research related to estimates based on recovery factor. The investigation continued in 1978-79, with development of a computer model and the application of computer methods. The economic overlay is now completed. A geological engineering paper should be completed by 1980-81. A licensing agreement has been made with the contracting company to make the data on recoverability available to the public on a user-pay basis.

The study of the Alberta portion of the Lloydminster area has been largely completed. The study of the Saskatchewan portion is underway.

78-79 Funds: \$50,000

79-80 Funds: \$0

Subprogram Director: Dr. D.F. Stott, Institute for Sedimentary and Petroleum Geology,  
Department of Energy, Mines and Resources, 3303-33rd St. N.W., Calgary,  
Alberta, T2L 2A7. 403-284-0110

1978-80

Task: Fossil Fuels  
Program: Oil Sands and Heavy Oils  
Subprogram: Oil Sands and Heavy Oil Resources (Sheet 2 - Assessment)

## OBJECTIVE

To provide detailed chemical descriptions of the molecular type components of bitumens, heavy oils, frontier oils, their processing products and fractions thereof.

## WORK

The well-established methods and tools for the characterization of the main fractions of conventional crude oils cannot, in general, be employed in the analysis of bitumens, heavy oils and heavy ends of conventional oils. In the United States valuable fundamental studies were carried out in connection with API Project 60 that dealt with heavy ends. New analytical and interpretive tools are being developed that are based to a large extent on the API studies and also on developments elsewhere for the characterization of Canadian resources.

In 1977-78 reports were submitted describing simulated geothermal maturation of Athabasca Bitumen and application of results for interpreting the degree of maturation of East Coast Oils. An evaluation was made on the viability of using bitumen as a source for petrochemicals (benzene, toluene, xylene). Changes in the chemical constitution of bitumen brought about by hydrocracking were studied.

In 1978-79 the development of new analytical-characterization methods continued. Work centres on the industrially interesting Lloydminster and Cold Lake heavy oils and their hydrocracked products. The need for support work is required for developing upgrading technology. In support of longer term goals, characterization methods are being developed for coal liquefaction products. Progress was made in the characterization of Lloydminster and Athabasca hydrocracked bitumen products. This involved 5 reports and another 4 reports described the development of analytical methods. Two reports described the progress on the economic separation of the nitrogenous components. Analytical services to outside agencies involved about 300 samples and over 1500 determinations.

In 1979-80 the work continued from the previous year on the characterization and analytical methods development. Joint work with the United States, Alberta and Saskatchewan agencies is planned on this subject. Patent applications on methods for the economic separations of nitrogenous components will be made. The analytical services to outside agencies continued.

These nitrogenous components and associated metals deactivate catalysts that are needed for upgrading; thus removal of major amounts reduces catalyst costs.

78-79 Funds: \$201,000

79-80 Funds: \$341,000

Subprogram Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth Street, Ottawa,  
Ontario, K1A 0G1. 613-995-4053.

Task: Fossil Fuels  
Program: Oil Sands and Heavy Oils  
Subprogram: Technology for Exploitation and Recovery (Sheet 1 - Characterization of Hydrocarbons)

#### OBJECTIVE

Oil from oil sand deposits is expected to contribute significantly in the next 50 years to supplies of fossil fuels. Current plants mine by open pit; deeper deposits will require either underground mining of the sands or in situ recovery of bitumen. Objectives are the improvement of existing open pit mining methods, development of techniques for underground mining and assessment of parameters affecting in situ extraction.

#### WORK

Results for 1978-79 included: an assessment of bucket wheel and dragline excavation methods; development of a non-linear finite element model of tar sands for use in predicting response to underground mining; and a field study of the mining characteristics of the limestone underlying the Athabasca oil sands (relevant to access for in situ recovery). Effort in 79-80 included an investigation of oil sand slurry characteristics and hydraulic cutting of oil sands in order to evaluate hydraulic mining of oil sands. A general review of oil sands mining is being produced.

In view of the effort of AOSTRA and others in oil sands mining, EMR effort has been recently reduced to a watching brief with an annual state of the art review.

78-79 Funds: \$186,000

79-80 Funds: \$33,000

Subprogram Director: Mr. R. Sage, Canada Centre for Mineral and Energy Technology, Department of Energy, Mines and Resources, 555 Booth St., Ottawa, Ontario, K1A 0G1.  
613-995-4295



1978-80

Task: Fossil Fuels  
Program: Oil Sands and Heavy Oils  
Subprogram: Technology for Exploitation and Recovery (Sheet 2 - Spherical Agglomeration; Hydrocarbon Analysis)

## OBJECTIVE

To develop an alternative oil-sand separation process that can be used for treatment of high-clay content oil-sands and hot-water process rejects. To develop quantitative methods for analyses of bitumens, heavy-oils and their hydrocracked products. To train and apprise in-house technical and professional staff of the capabilities of  $^{13}\text{C}$  nuclear magnetic resonance spectrometry for process problem solution.

## WORK

The currently used hot-water separation process cannot effectively treat high-clay sands without the formation of severe levels of oil-water-clay emulsions. Currently these materials (15%) are stockpiled or blended with low-clay sands. The NRC spherical agglomeration overcomes emulsion formation.

During 1977-78 equipment was ordered and delivered for construction of an improved design of the spherical agglomerator. A pilot plant test was run under contract.

Work is continuing on the continuous separation of bitumen from oil sands, using a novel two-stage solvent extraction/sand agglomeration technique combined on a single unit. Operation of the unit has indicate bitumen recoveries greater than 90% even for low grade feeds containing 50% fines.

Batch tests have been used to study the effect of wetting agents on the retention of solvent in the agglomerates. Certain types of non-surface active agents have been found to be effective in reducing solvent retention in the tailings. Experiments are being conducted to evaluate the possibility of residual solvent recovery from agglomerates without flashing off too much water.

Bench scale agglomeration tests on oil-sands of different clay contents indicated that the organic matter separated using varsol, naphtha or toluene is approximately proportional to the +44 mineral matter present in the feeds. The phenomenon appears to be independent of the method of extraction.

Promising results have been obtained using agglomeration methods for recovering emulsified bitumen from the hot water process sludge pond. Exploratory studies indicated that the aqueous tailings after the bitumen removal appears to become less stable after the addition of the agglomerates from the spherical agglomeration process. This is a very important economic factor since it is cheaper to pipe-line the solvent stripped agglomerates into the existing tailings pond. Further work along these lines is being contemplated.

Another contract to carry out further oil-sand work leading to a 100 ton per day demonstration plant is being negotiated.

(continued on next page)

Task: Fossil Fuels  
Program: Oil Sands and Heavy Oils  
Subprogram: Technology for Exploitation and Recovery (Sheet 2 - Spherical Agglomeration; Hydrocarbon Analysis)

(continued from previous page)

NNR Studies of Oil Sands - Hydrocarbon Analysis

Several exploratory studies of oil sands have been undertaken since the Bruker CXP-180 NMR Spectrometer has been operational.

Individual  $^1\text{H}$  lines are not observed for bitumen and water. Half peak intensity line widths range from 1.5 kHz for high grade Tar Sands (low clay content) to 25 kHz for a sample of high-fines content, the values roughly reflecting the "viscosity" of the bitumen. The 20-30% increase in line width produced by the removal of water also may be attributed to decreased motional averaging of local magnetic fields.

The number ratio of aromatic to aliphatic carbon atoms may be readily measured from natural-abundance  $^{13}\text{C}$  NMR with gated decoupling or proton enhancement techniques. There is a rough correlation between this ratio and  $^1\text{H}$  line widths (and hence viscosity)  $^1\text{H}$  and  $^{13}\text{C}$  measurements may be used to give total H and C atom contents.

Special Report - Some Properties of the Tailings After the Separation of Bitumen from the Athasbasca Oil Sands by Agglomeration Methods, by A.F. Sirianni.

78-79 Funds: \$262,000

79-80 Funds: \$262,000

Subprogram Dr. D.W Davidson, Colloid & Clathrate Chemistry, National Research  
Director: Council, Montreal Road, Ottawa, Ontario, K1A 0R6. 613-993-2011

Task: Fossil Fuels  
Program: Oil Sands and Heavy Oils  
Subprogram: Technology for Exploitation and Recovery (Sheet 3 - Bitumen/Heavy Oil Separation and Extraction)

## OBJECTIVE

To support the development of alternative oil-sand separation processes: to deal with environmental concerns such as clay sludges in tailings ponds.

## WORK

A limitation to the economic development of surface mined oil sand resources is the hot-water separation process currently in use. Although the process works effectively (over 90% recovery) on the rich portion of oil-sands fed to the extraction units, problems arise with high clay content sands and from the negative environmental impact of the separation plant water/sand/clay reject settling ponds.

A significant contributor to the need for extensive settling ponds is the colloidal dispersion of clay brought about, in part, by the use of caustic in the hot-water process. Several agencies, including AOSTRA, Alberta Research Council and the NRC, as well as industry, are investigating alternative separation processes.

CANMET has contributed to the funding of a shared contract with industry for the completion of 1 tonne/hr pilot plant tests of a cold-water separation process. Improvements have been made and tested for modifications to the feed reduction system, the slurry forming systems and the oil-water separation systems. An integrated process design and feasibility study for a full-scale plant has been completed. The report from this study is being presented to potential industrial users for evaluation. Design of a 30 tonnes/hr pilot plant will be undertaken after a major reassessment of the initial design study.

CANMET has carried on a limited effort in dewatering clay studies from current hot water operations by electrokinetic methods. While it is possible to remove the greater portion of the water to give hard materials the electric power costs are too high for application. CANMET has also been concerned with the development of very powerful surfactant by petroleum metabolizing bacteria by total support of efforts being made at the University of Western Ontario. At some concentrations these surfactants can be useful for separation of bitumen from sand while at other concentrations there is evidence that they might be useful for emulsion breaking. Biological surfactants or derivatives and modifications are being studied for emulsion breaking properties. There are also some in-house efforts on the breaking of emulsions of in situ operation through joint efforts with and funded by industry. Considerable progress was made using various synthetic surfactants as well as in the characterization of emulsions.

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1978-80

Task: Fossil Fuels

Program: Oil Sands and Heavy Oils

Subprogram: Technology for Exploitation and Recovery (Sheet 3 - Bitumen/Heavy Oil Separation and Extraction)

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Economic studies are in progress for the use of coal as a fuel for both in-situ operations and bitumen separations from mined feed in combination with various upgrading processes. Economic comparisons are also made for in-situ combustion operations. CANMET has totally supported investigation for establishing solvent bitumen extraction parameters at the University of Toronto. This work has been completed and reported. It will be critically reviewed.

There is also involvement in the Canada Saskatchewan heavy oil agreement and the CANMET laboratories are prepared to give support when needed.

A study concerning the relationship of the surface properties of clays to oil/water emulsion stability is being conducted at the University of Toronto under contract.

78-79 Funds: \$508,000

79-80 Funds: \$243,000

Subprogram Director: Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4053



1978-80

Task: Fossil Fuels  
Program: Oil Sands and Heavy Oils  
Subprogram: Technology for Exploitation and Recovery (Sheet 4 - Hydrocracking)

## OBJECTIVE

To develop and improve the technology for increasing the amounts of useful liquid products which can be obtained from bitumen and heavy oils.

## WORK

A major activity recently has been the commercialization of the CANMET hydrocracking technologies which can increase liquid yields by as much as 16% above those obtainable from the currently used carbon rejection (coking) technologies. Projects connected with this work and other technologies for improving liquid yields are described below.

The process which CANMET has successfully developed is a high temperature hydrocracking technology (called the CANMET Hydrocracking Process), using slurry additives to convert the pitch fraction to distillable materials. This process produces 10 to 15% higher distillate yields from Athabasca bitumen than the competing processes based on coking, or carbon removal. During 1978-79 various companies submitted proposals for licensing the CANMET Hydrocracking Technologies. The proposal outlining a joint venture company under the leadership of Petro-Canada was chosen as best meeting technical, commercial, marketing and industrial benefit to Canada criteria. The technology is being developed further and considerable progress was made during the year to allow high conversion operations at lower pressures, thereby reducing capital costs. Also substantial progress was made to increase the degree of desulphurization that occurs during the hydrocracking. The technology was applied to various feedstocks besides Athabasca bitumen. 17 patent applications on various aspects of the technology development were made in several relevant countries. In addition 26 reports were prepared on the technology development. The arrangements that have been negotiated with Petro-Canada allow none of this information to be disclosed. Cooperative efforts for commercialization of these technologies.

The secondary refining of products from the first stage upgrading of bitumen is important to obtain complete data on total hydrogen consumption and operating conditions required to meet the synthetic crude specifications. A hydrotreater pilot unit was modified so that hydrogen consumption measurements could be obtained. Hydrotreating experiments were carried out using a commercial catalyst (3 wt % NiO - 12 wt % MoO<sub>3</sub> on alumina). Experiments were completed for the liquids obtained from the high and low conversion thermal hydrocracking of bitumen: naphtha; light gas-oil; and heavy gas-oil. These results will be used to support the study on the economics of hydrocracking processes and to complete the "technology package".

Several contracts were awarded for 1977-78 and 1978-79 to involve the private sector during the development of the CANMET hydrocracking technology and to provide

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Task: Fossil Fuels  
Program: Oil Sands and Heavy Oils  
Subprogram: Technology for Exploitation and Recovery (Sheet 4 - Hydrocracking)

(continued from previous page)

necessary backup support. The following contracts were awarded: Solubilities of hydrogen and hydrogen sulphide in bitumen and hydrocracked products; ESR studies of benzene insolubles from reactor liquid and heavy end samples; thermal properties of bitumen and hydrocracked products; and economic studies on utilization of pitch particularly gasification for hydrogen production.

Other work of the past few years is described below.

During 1977-78 evaluations were made of improved methods for thermal hydrocracking of Athabasca bitumen, Cold Lake bitumen and Lloydminster heavy oil. For Athabasca bitumen, topping was found to improve pitch conversion and reduce the (expensive) hydrogen consumption per ton of pitch converted. Topping Athabasca bitumen also reduced the degree of reactor coking. These results formed the basis of a patent application. Several short, exploratory tests and one long process viability test were carried out with 650°F+ topped Cold Lake bitumen. Short, exploratory tests were also completed for Lloydminster vacuum residue. Further process demonstration was being carried out during 1978-79 to evaluate process operability through optimization of processing parameters for additional types of feedstocks of industrial interest.

78-79 Funds: \$1,562,000

79-80 Funds: \$1,829,000

Subprogram Director: Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4053

1978-80

Task: Fossil Fuels

Program: Oil Sands and Heavy Oils

Subprogram: Technology for Exploitation and Recovery (Sheet 5 - Catalyst Development)

## OBJECTIVE

To study and develop catalysts for hydrocracking/desulphurization/denitrogenation reactions for rapid catalyst deactivation during bitumen/heavy oil and products processing. To produce low cost throwaway catalysts as well as catalysts with longer useable lifetimes and thus lower the catalyst costs. To study catalytic pitch gasification reactions.

## WORK

A major problem with conventional catalytic hydrocracking and desulphurization is rapid catalyst deactivation and the consequent high and costly replacement rate. This problem is approached by attempting to produce low cost throwaway catalysts and also to produce catalysts with longer useable lifetimes. In case of the former low cost materials with catalytic properties are sought. In the case of the latter catalysts are being formulated for increased resistance to fouling and by increasing pore sizes so that deactivation occurs throughout the catalyst rather than at the pore mouth or external surfaces. Pitch gasification is needed for utilizing high sulphur pitch (hydrocracked distillation residue) and producing a convenient fuel. Catalytic gasification studies are being made to see if the cost of the gasification units can be reduced.

During 1978-79 facilities for the rapid evaluation of the deactivation rates of catalysts were established. This allows quick comparisons of catalysts that are being developed. Also facilities are being established for characterizing catalyst surfaces at various levels of deactivation by X-ray photoelectron spectrometry. Various tin containing catalysts were prepared and tested but although they had durable properties for coal hydrogenation they were found to be of no value for bitumen processing. The promotion of molybdate catalysts with alkali metal, particularly sodium has been found to be quite effective for increasing deactivation resistance and this is being investigated. The studies on pore sizes of some catalysts showed that increasing the average pore size from increased resistance to deactivation by metals inherent to bitumen. However, maximum desulphurization occurred at smaller average pore diameters. In the pitch gasification studies it was shown that various catalysts were beneficial and others had detrimental effects.

In 1979-80 the facilities for the X-ray photoelectron spectrometric characterization of catalyst surface were being completed. Also facilities for actual testing of the ageing of catalysts over extended periods of time were being completed. The various pitch gasification parameters with and without catalysts were investigated using a continuous gasification.

78-79 Funds: \$434,100

79-80 Funds: \$371,000

Subprogram Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4053

1978-80

Task: Fossil Fuels  
Program: Oil Sands and Heavy Oils  
Subprogram: Materials for Production and Processing of Oil Sands and Heavy Oils

## OBJECTIVE

To identify and solve materials problems in the production and processing of oil sands and heavy oils by means of cooperative program with the industries involved.

## WORK

Excessive wear of oil sands tailing slurry pipelines, experienced by Syncrude, has been identified as an area where cooperation between CANMET and Syncrude can have significant economic impact. The results of this R&D program should benefit future oil sands operators. Perhaps a more severe materials problem, however, is likely to occur in the corrosive/abrasive environments accompanying in-situ recovery of both heavy oils and tar sands. With commitments for in situ recovery of heavy oils already made by Imperial and Petro-Canada and interest by several major oil companies in in situ recovery of tar sands, the potential for a cooperative materials R&D program exists. Initial effort will be devoted to identifying and prioritizing materials problems after which a cooperative program will be developed.

The attempts now being made to commercialize EMR hydrocracking process may result in the need for a continued materials effort to complement developments in process technology at both the laboratory and commercial stage.

During 1978-79 the refinement of a novel test method was accomplished which will now permit isolation of the corrosive and erosive components of wear in tar sand tailings slurry pipelines.

A review of the materials requirements for construction and operation of hydrocracking pressure vessels was completed. Future Canadian oil and gas processing projects have been identified as a base on which to determine materials R&D needs.

The work in 1979-80 included the following projects. Evaluation of corrosion/erosion resistance of one experimental wear resistant steel and characterization of wear of three commercial steels in actual tailing sand slurries. Development of an R&D program to investigate materials problems occurring or likely to occur during in situ recovery of both heavy oils and tar sands. On the basis of a comprehensive study to identify critical materials problems likely to be encountered in operation of a hydrocracking plant using EMR process technology, to develop a materials R&D program for investigation of such problems at pilot scale where feasible.

78-79 Funds: \$50,000

79-80 Funds: \$103,000

Subprogram Dr. R. Thomson, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4044

1978-80

Task: Fossil Fuels  
Program: Coal Gasification and Liquefaction  
Subprogram: Experimental Gasification (In-house Work)

## OBJECTIVE

The objectives of this in-house project are: to build experimental bench-scale equipment in ERL to determine the effect of key process variables on the characteristics of gasification to low and medium Btu gas of Canadian coals, pitch/coal and bitumen/coal mixtures; and to monitor and evaluate current state-of-the-art technology on coal gasification and to investigate new research ideas.

## WORK

In 1978-79 a bench scale atmospheric gasifier capable of operation at temperatures up to about 1000°C was commissioned. Another gasification unit, a high pressure thermobalance reactor capable of operation at 2500 psi and 1000°C was completed. A conceptual design of a flexible continuous gasifier that will allow pressurized operation in fixed, fluidized and entrained bed modes was being developed.

Work in 1979-80 included:

- Reactivity parameters for three Canadian coals during gasification in an atmospheric fixed bed reactor.
- Reactivity parameters for one Canadian coal in a high pressure gasification system developed from thermobalance data.
- Design of one continuous high pressure gasifier for laboratory process studies.

78-79 Funds: \$251,000

79-80 Funds: \$460,000

Subprogram Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4053



Task: Fossil Fuels  
Program: Coal Gasification and Liquefaction  
Subprogram: Experimental Liquefaction (In-house Work)

## OBJECTIVE

(1) To characterize coal liquefaction processes, or combinations of processes, suitable to the petrography of Canadian coals and the economics of alternative fuels supply, especially in relation to the costs of liquid fuels from tar-sand and heavy-oil deposits. (2) To develop bench-scale test facilities (both continuous and batch) in-house to characterize the coal liquefaction propensities of Canadian coals. Also includes the relationship between petrographic characteristics and liquefaction potentials. (3) To study the co-processing of bitumen and coal using hydrocracking technology to produce additional liquid fuels.

## WORK

During 1977-78 the main effort was in reactor design and equipment purchase. Two experimental units are presently under construction. The continuous feed coal-liquefaction unit is scheduled for commissioning before January 1980, and the solvent preparation unit should be commissioned by June of 1980. These units will compare the liquefaction behaviour of different Canadian coals using bitumen and bitumen fractions as slurry-solvents.

The required facilities being established include a continuous feed coal liquefaction unit and a continuous hydrogenation/hydrocracking reactor system.

78-79 Funds: \$151,000

79-80 Funds: \$323,000

Subprogram Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4053



1978-80

Task: Fossil Fuels  
Program: Coal Gasification and Liquefaction  
Subprogram: Conversion Contracts (Process Development)

#### OBJECTIVE

To stimulate coal conversion work within Canadian organizations.

#### WORK

This work can be placed into two broad groups. First, cost studies which are to examine application of new coal technology to the present supply, manufacturing, and marketing conditions. Second experimental studies to develop and scale-up new coal technology. Organizations performing the above studies have included major utilities, major manufacturing companies, coal mining firms, and provincial research institutes. The federal government provides a maximum of 50% of the cost of performing these studies.

#### Projects:

- studies on firing a coal oil slurry in a utility boiler
- a technical and economic evaluation of 4 processes for small scale (2-30x10<sup>9</sup> Btu/day) coal gasification
- coal/oil slurries for blast furnace injection
- thermal drying (non-evaporative drying) of lignite
- low severity coal liquefaction studies
- the utilization of CO flue gases
- combustion of coal/oil slurries
- blending of methanol and diesel fuel
- flash pyrolysis (100% funded)

This and the following contract program were reorganized in 1978-79.

The funds below are for Subprograms 2.2.4 and 2.2.5.

78-79 Funds: \$1,000,000

79-80 Funds: \$1,000,000

Subprogram Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4053

Task: Fossil Fuels  
Program: Coal Gasification and Liquefaction  
Subprogram: Conversion Contracts (Research and Development)

## OBJECTIVE

This element of the coal conversion program contracts out experimental R&D work elements of limited scope to researchers in industrial research centres, para-public research centres and university laboratories. The objectives are: (a) to stimulate the growth of human resource basis and to develop expertise in this field which is relatively new to Canada; (b) to carry out exploratory research and development on new and advanced technologies applicable to Canadian coal conversion problems and coal industry; and (c) to solve specific problems related to the adoption of these new technologies in Canada.

## WORK

Fifty-three letters of intent were received for the year 1977-78; 24 requests for proposals were requested and 8 proposals were accepted for funding. The contract titles are:

- reactivity of lignites for gasification
- hydrogenation of coal during grinding
- to obtain rheological data on coal oil slurries to design transfer lines
- to develop a low BTU gas burner
- to design build and operate a spouted bed gasifier for caking coals
- upgrading coal in an electrothermal fluidized bed
- to design build and operate a bench scale gasifier
- reaction kinetics of thin carbon and coal films.

Studies have also been made of the application of flash pyrolysis to the treatment of high, medium and low volatiles bituminous coals and lignite.

This and the previous contract program were reorganized in 1978-79 and are described on the following pages.

For funding see Subprogram 2.2.4.

Subprogram Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4053

Task: Fossil Fuels  
Program: Coal Gasification and Liquefaction  
Subprogram: Contracts for Gasification

#### OBJECTIVE

The objectives of these research contracts are to encourage the industrial application of gasification (both in combined cycles and independently) as alternatives in industrial energy cascade systems. Also to encourage the development understanding of gasification technology in universities and industry.

#### WORK

During 1978-79 the following contracts were 50% funded by the federal government as joint efforts with industry:

Technical and Economic Assessment of Small Gasifiers using Saskatchewan Coals by Saskatchewan Power Corp.

Shaunavon Gasification Combined Cycle Electricity Generation Study by Saskatchewan Power Corp.

#### 100%-funded Contracts:

Determination of Reactivities of Saskatchewan Lignites for Gasification by Saskatchewan Power Corp. This study included comparing the reactivities of the various coal maceral so that indication of the lignite reactivities might be obtained by inexpensive optical petrographic analysis.

Gasification of Caking Coals in a Spouted Bed by the University of B.C.

Reactivity of Coal and Carbon Films for Gasification by the University of Ottawa.

Optimization of Processes for the Generation and Combustion of Coal Gas by Carleton University.

For 1979-80 the following contracts were 50% funded:

Lignite Reactivity Studies by the Saskatchewan Power Corp. This is an extension of the contract that was funded 100% in the previous year.

Shaunavon Gasification Combined Cycle Electricity Generation Study by Saskatchewan Power Corp. - this is a continuation from the previous year.

#### 100% Funded Contracts:

Spouted Bed Gasification of Caking Coals - this is an extension of the contract of the previous year.

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Task: Fossil Fuels  
Program: Coal Gasification and Liquefaction  
Subprogram: Contracts for Gasification

(continued from previous page)

Product Control - Fluid Bed Gasification

Molten Salt Coal Gasification

Solid Product Characterization for both Gasification and Liquefaction Studies.

The funds below are Subprograms 2.2.6 and 2.2.7.

78-79 Funds: \$1,187,000

79-80 Funds: \$1,187,000

Subprogram Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4053

1978-80

Task: Fossil Fuels  
Program: Coal Gasification and Liquefaction  
Subprogram: Contracts for Liquefaction

#### OBJECTIVE

The objective is to encourage the development of coal liquefaction R&D and demonstration within Canadian industry and academic institutions.

#### WORK

During 1978-79 the following investigations were made under contract:

50%-funded - Low Severity Coal Liquefaction Technology for Nova Scotia Coal by the Nova Scotia Research Foundation.

100%-funded - Concurrent Hydrogenation and Grinding of Coal by the B.C. Research Council.

Potential Liquefaction of Low Rank Coals as Future Source of Liquid Fuels.

An Economic Study of Coal as a Make-up Energy Source in Oil Sands by In situ Research and Engineering Ltd. This represents an indirect means of using coal for generating liquid fuels in which coal is used to increase liquid yield from the processing of bitumen/heavy oil. It also involves the gasification processes.

For 1979-80 the following contracts were considered:

50% Funding - Coal Liquefaction Experimental Study. This is an extension of work that was 100% funded in the previous year.

- Experimental-Economic Evaluation of a Coal Liquefaction Technology, a shared contract among industry, Alberta and EMR (initiated 1979-80).

100%-funded - Coal Liquefaction Process Evaluation by SNC. This involves selection of the best processes for liquefaction of appropriate Canadian coals. Actual testing will be done in existing facilities in other countries.

Oxygen Removal from Low Rank Coals

Supercritical Gas Extraction of Coals

Bitumen/Heavy Oil Refining of Coals

Flash Hydropyrolysis of Coals

For funding see Subprogram 2.2.6.

78-79 Funds: \$1,187,000

79-80 Funds: \$1,187,000

Subprogram Director: Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4053



1978-80

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Geoscience Concepts Related to Coal Resources

## OBJECT

To provide the geoscience base for the coal measures in Canada.

## WORK

The study of geoscience concepts applicable to both eastern and western Canadian coals indicates increased potential for coal resources in Canada. Coal seams of suitable thickness and quality for mining have been outlined by drilling offshore from Cape Breton Island, Nova Scotia, and in the upper Elk River valley British Columbia. In addition, surface mapping of the Dominion Coal Block in southeastern British Columbia and of the Bonnet Plume Basin in central Yukon Territory has identified promising resources, the former of metallurgical coals, and the latter of coals suitable for power generation. Examination of the low grade, lignite coals of central British Columbia suggests that with the exception of Hat Creek most of the deposits have limited economic value. Drilling of selected occurrences is essential to the substantiation of this conclusion.

Petrographic examination of the Kootenay coals in the Crowsnest Pass area confirms that coking quality is optimum toward the middle of the section. Should the technology of hydraulic mining be extended to seams as thin as three metres, these mid-Kootenay coals should be given careful study because of their metallurgical potential.

Sedimentological studies in the Foothills of Alberta and British Columbia are providing precise paleogeographic models of the coal measures and, in turn, predictive tools in prospecting for coal.

Projects in this Subprogram may be grouped as follows:

- stratigraphic and structural studies of the coal measures
- development of sedimentological and structural models of coal basins
- assessment of quality and coking characteristics of Canadian coals
- environmental assessment of coal resource development
- coal seam correlation.

78-79 Funds: \$702,000

79-80 Funds: \$752,000

Subprogram Dr. D.F. Stott, Institute for Sedimentary and Petroleum Geology,  
Director: Department of Energy, Mines and Resources, 3303-33rd St. N.W., Calgary,  
Alberta, T2L 2A7. 403-284-0110

GOVERNMENT OF CANADA

1978-80

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Resource and Reserve Assessment (Quantity and Location)

## OBJECTIVE

To assess Canada's coal resource and to convert to reserves.

## WORK

The objective was advanced significantly with the completion of the geological report and atlas on the lignite deposits of southern Saskatchewan in 1977-78. It was published jointly by EMR and the government of Saskatchewan in 1978. The revised resources in thermal coals arising from this project have been released (EMR publication EP 77-5, see bibliography), and document that there should be no shortage of this commodity for several decades. Moreover, the assessment of the thermal coal resources of the Alberta Plains embraced by the Dodds-Roundhill Project has been completed from raw data provided by industry. More than 500 million tons of resources of immediate interest have been delineated at drilling depths of less than 150 feet.

A contract to incorporate data on the deep coals of Alberta from boreholes into a computer file is complete and is being extended to the Plains of Saskatchewan, Manitoba and British Columbia.

The resource assessment methodology developed for the flat lying seams of Saskatchewan has been extended under contract to include conditional probabilities. A methodology similar to that used in estimating hydrocarbon resources will soon be used for coal.

Projects in this subprogram include:

- Estimation of the coal resources of the various coal basins in Canada
- Development of computer technology for evaluation of the resource potential of the deep coals of the Interior Plains.

The resource assessment subprogram is on-going. It has milestones corresponding to completion of evaluation of each basin, and is very much dependent on cooperation with the coal producing provinces and industry.

78-79 Funds: \$95,000

79-80 Funds: \$95,000

Subprogram Dr. D.F. Stott, Institute for Sedimentary and Petroleum Geology,  
Director: Department of Energy, Mines and Resources, 3303-33rd St. N.W., Calgary,  
Alberta, T2L 2A7. 403-284-0110

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Resource and Reserve Assessment (Quality and Recoverability)

## OBJECT

To develop an adequate inventory of Canadian coal and assess its quality including coking characteristics.

## WORK

The Geological Survey of Canada has established a substantial computer data base for western Canadian coal resources, particularly for plains coals. In 1980-81, British Columbia coal resources are being added to the data base in conjunction with provincial authorities and producers.

CANMET continues routinely to assess coal quality, with samples from eastern and western Canada; the framework for a fuel-peat data base has been developed.

In 1980-81, geophysical logging techniques will be assessed, with a view to enhancing the coal quality data obtained from down-the-hole logging.

Development of reserve assessment methodology has been suspended pending a review of the needs for and concepts behind national reserve assessment. In 1980-81, the Bonner and Moore surface coal mining simulator will be evaluated to assess its usefulness to Canadian producers.

78-79 Funds: \$830,000

79-80 Funds: \$876,000

Subprogram R. Sage, Canada Centre for Mineral and Energy Technology, Department of  
Director: Energy, Mines and Resources, 555 Booth St., Ottawa, Ontario, K1A 0G1.  
613-995-4295

1978-80

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Mining Technology

## OBJECT

To stimulate the adaptation of safer and better mining systems and subsystems to increase economic exploitation of domestic fuel resources, particularly coal for the near term.

## WORK

Reports, publications and conference presentation detailed progress on study of multiple seam ground control interactions at Smoky River, Alberta; thick seam strata control at Sparwood, British Columbia; and, a review of underground strata control parameters in western Canada as a contribution towards a better understanding of how to design mining systems for safer and higher extraction of coal in the Rocky Mountain region.

Similarly in-mine and contract studies were reported dealing with drainage and face control of methane. A further contract dealt with avoidance of methane roof layering explosions. In-house studies also reported on spontaneous combustion, CO monitoring and ventilation field studies. The objective of the mine environment work is to ensure continuous and safe mine operations. To this end electrical and diesel equipment as well as construction and supply materials for underground use were certified and where necessary subjected to research and regulated by adequate acceptance standards.

This has good potential for increasing efficiency. Ground control measurements in the Kaiser hydraulic mine are in hand, and will lead to procedures for predicting ground behaviour during hydraulic mining, facilitating spread of this method. Work began on development a system for complete underground environmental monitoring. Methane emission characteristics in varying ground conditions and for various coals have been determined. Good progress has been made in improving test procedures for certification of underground equipment, and in setting proper standards. An improved diesel flame trap has been developed, and a draft Canadian flameproof diesel code developed.

An evaluation of punch mining from a plains open pit high-wall was completed early in 1980. During 1980-81, a trial of short-wall mining of plains coal, in conjunction with Petro Canada and the Coal Mining Research Centre will take place. The operating characteristics of bucketwheel excavators for surface coal mining (overburden removal) will be assessed.

78-79 Funds: \$817,000

79-80 Funds: \$842,000

Subprogram R. Sage, Canada Centre for Mineral and Energy Technology, Department  
Director: of Energy, Mines and Resources, 555 Booth St., Ottawa, Ontario,  
K1A 0G1. 613-995-4295



Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Coal Preparation

## OBJECTIVE

To develop efficient preparation technology with respect to Canadian coals.

## WORK

Efficient coal preparation is becoming increasingly important for maintaining competitiveness for Canadian metallurgical coals, and will become significant for thermal coals (in reducing pollution and transport costs) and for coal conversion to liquid or gas fuels. Particular aspects of immediate importance include improved water treatment for recycling and environmental requirements, selection of optimum preparation procedures for new coals, recovery of coal from prep plant rejects and recovery of fines. Development and demonstration of novel processes will be important; oil agglomeration, particularly in the context of coal-in-oil combustion is a prime example.

During 1979-80, the Edmonton coal preparation pilot was extended, and a 150 kg/hr mini-plant commissioned as an adjunct. An automated ash monitor was developed to the prototype stage, as was an automatic settling rate measuring instrument. Correlation of gas absorption/desorption and degradation characteristics was established as a viable technique. High gradient magnetic separation was shown to be potentially valuable as a technique for removing ash, including pyrite. A mobile water treatment plant has been assembled and has completed preliminary testing. Good results were achieved in characterizing and synthesizing flocculants.

In 1980-81, improved flotation cells and a Batac jig will be added to the coal preparation pilot plant. The mobile water treatment plant will be fully commissioned through field trials at a coal washery and synthetic flocculants manufactured to CANMET specifications.

Chemical comminution studies, using ammonia to develop fractures within coal, will continue, and two long-term projects will begin: development of techniques to characterize and improve the preparation behaviour of fire, oxidized coal; and development of complete computer simulation of coal preparation circuits. The latter potentially will benefit both users of existing washeries, and designers of new plants.

NRC's coal agglomeration technology has been successfully demonstrated at Devco's Victoria Junction plant, and is being used in coal-oil mixture studies in the Maritimes. An NRC unit will be included in both the Western Research Laboratory, (Edmonton) coal preparation pilot plant and in the mobile water treatment plant.

78-79 Funds: \$900,000

79-80 Funds: \$958,000

Subprogram Mr. R. Sage, Canada Centre for Mineral and Energy Technology, Department  
Director: of Energy, Mines and Resources, 555 Booth St., Ottawa, Ontario,  
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1978-80

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Carbonization

## OBJECTIVE

To achieve self reliance in the use of Canadian Coals for the steel industry; to provide assistance to the Canadian steel and coal industries; and to work in close coordination on a cost sharing basis with the Canadian Carbonization Research Association.

## WORK

Early work in this subprogram consisted of: conventional cokemaking in slot-type coke ovens with assistance to the steel and coal industries (mainly cost recovery basis); characterization of coals for cokemaking; advanced cokemaking and coke properties; resource evaluation; and technology exchange.

Results and continuing work follows. Coals of more than 10 seams have been evaluated for their coking properties. This involved both eastern and western coals in various blends. Some of these evaluations were made for foreign customers. New carbonization facilities have been commissioned in Edmonton. Substantial progress has been made in the development of technology that allows the use of marginal or even non-coking coals for making good quality coke. Asphalts, pitches and coal derivatives were found to be useful additives for the production of metallurgical strength coke from poor or non-coking coals. Preheating experiments showed that for some coals the coke quality increased while for others it decreased. The use of high bulk density charges techniques were found to increase the quality of eastern coals that possess high volatile matter and high fluidity. The effect of various carbonization variables on coke quality were investigated. Pulverization was found to be beneficial but selective pulverization tests so far were disappointing. Tests will be made on blends containing coals with high content of inert materials.

Considerable progress has also been made in the restoration of the coking properties of partially oxidized or weathered coals. The addition of a heavy oil fraction from Athabasca bitumen was found to be quite effective. Also, a thermal treatment with carbon monoxide was very effective and this is the subject of a patent application.

Some investigations have been made into advanced cokemaking technology such as form coking. A Turkish UNIDO fellow developed a method for obtaining satisfactory form coke from Saskatchewan lignites that are similar to some Turkish lignites. The development of new coking technology will be continued. There is a continuous development of new methods for predicting the coke strength from coal characteristics using physical bench scale tests, petrography and chemical parameters. This requires much characterization and studies on coal constitution with the need for work in standardizing methods of carbonization tests. The coke quality of the various ovens is being compared frequently and relevance to commercial scale ovens is being studied. Methods for determining the reactivities

(continued on next page)

1978-80

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Carbonization

(continued from previous page)

and coke strengths are being assessed and modified for more relevance to the requirements of the steel industry. This involves much cooperation with outside agencies. A meeting with the International Standards Organization was hosted.

78-79 Funds: \$528,000

79-80 Funds: \$568,000

Subprogram Mr. R. Sage, Canada Centre for Mineral and Energy Technology, Department  
Director: of Energy, Mines and Resources, 555 Booth St., Ottawa, Ontario, K1A 0G1.  
613-995-4295

1978-80

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Sulphur Removal from Coal during Coking

#### OBJECTIVE

To study the desulphurization of coal under different processes.

#### WORK

The work forms part of a co-operative project on desulphurization of coal conducted under the auspices of the Atlantic Group for Research in Industrial Metallurgy. Members of the group presented papers on their research at the 28th Canadian Chemical Engineering Conference, Halifax, 1978. The papers are being published in the Proceedings of the Coal and Coke Sessions.

Various coals and blends are coked in a temperature-programmed, stainless steel, retort in batches of 1.5 kg. The evolution of six main gaseous components, including  $H_2S$ , were followed using an on-line mass spectrometer and mini-computer. Gases can be injected into the bed of coal as it is being coked.

Results: The emission spectrum of  $H_2S$  varies with the type of coal, and is a characteristic of coal. Variations are probably due to the ratio of organic to inorganic sulphur, the types of organic sulphur, and the size of the pyrite inclusion. The amount of sulphur removed from current coking coals as  $H_2S$  when they are heated to  $1000^\circ C$  depends upon the heating rate - increasing the heating rate increases the amount of sulphur given off as  $H_2S$ . This trend is not true for the other gaseous products of coal pyrolysis such as  $H_2$ ,  $CH_4$ ,  $CO$ ,  $CO_2$ , and  $C_2H_6$ . The injection of coke oven gas ( $H_2S$ -free) into a bed of coal as it is being coked is not efficacious for removing additional sulphur with the currently-used coking coal. This may be due partly to the small size of pyrite inclusions in the blends. Other coals may be more susceptible to such a process.

Projections: (1) The effect of heating rate upon liberation of  $H_2S$  will be studied further, employing the mass spectrometer. A variety of coals will be examined. (2) The effect of injected  $H_2S$ -free gas upon coals other than current coking coals being used will be studied. (3) The nature of the pyrite inclusions in coal and their changes upon coking, will be examined using a SEM/microprobe.

78-79 Funds: \$167,000

79-80 Funds: \$125,000

Subprogram Dr. S.G. Whiteway, Atlantic Regional Laboratory, National Research,  
Director: Council, 1411 Oxford St., Halifax, Nova Scotia, B3H 3Z1, 902-426-8269.

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Participation in IEA Activities (Sheet 1 - IEA Economic Assessment)

## OBJECTIVE

To support Canada's commitment to the IEA Economic Assessment Service (EAS).

## WORK

The need for maintaining an increased awareness of coal supply, processing, and utilization at the international level has led Canada to sign an implementing agreement with IEA Economic Assessment Service. EAS was set up to evaluate the application of coal conversion techniques and to formulate new research projects. Although emphasis is on coal conversion and pollution control technology, studies include coal supply economics and trade and transport of coal or coal-based energy. These interests facilitate EAS liaison with the other IEA Coal Research services to which Canada belongs - the Reserves and Resources Service, Mining Technology Clearing House, and Technical Information Service.

The program up to the end of March 1979, consisted of nine studies. Four of these are concerned with assessment of coal conversion (and power generation) technology and three with coal supply, transport, and trade, and one broad study to assess the economics of pollution control in selected areas associated with coal. A final study deals with the relative economics in the market place of different coal-based uses and included views of the economics of other primary energy sources.

78-79 Funds: \$133,000

79-80 Funds: \$125,000

Subprogram Dr. P.J. Read, Coal, Energy Policy Sector, Department of Energy, Mines  
Director: and Resources, 580 Booth St., Ottawa, Ontario, K1A 0E4. 613-995-9351.

1978-80

Task: Fossil Fuels

Program: Coal Supply

Subprogram: Participation in IEA Activities (Sheet 2 - IEA Resources and Reserves)

## OBJECTIVE

To support Canada's role in the World Coal Reserves and Resources Service.

## WORK

The World Coal Reserves and Resources Service was established to acquire and provide information on coal resources and reserves in a system where the data can be compared, despite differing national conventions, and readily updated and revised. In addition to providing a common basis of assessment, the Service aims to provide alternative assessments which allow for new technologies and markets.

In 1977-78 a Data Bank, linked by satellite to Service headquarters in London, was established in Reston, Virginia in conjunction with the US Geological Survey. The initial phase of data collection was completed, providing location and information on each of the world's known coal deposits. Initial entries have been prepared for the lexicon which is being developed as an aid to translate information gathered from different countries into the convention specified by the enquirer.

In 1978-79 the collection, validation, and banking of new resource/reserve data and updating of banked data continued. It is intended that the World Coal Reserves and Resources should be capable of objective assessment of coal reserves under varying parameters.

Canada withdrew from this activity in 1979-80.

78-79 Funds: \$34,000

79-80 Funds: \$0

Subprogram Dr. D.A. Reeve, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4060



1978-80

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Participation in IEA Activities (Sheet 3 - IEA Coal Technology Information Service)

## OBJECTIVE

To support Canada's contribution to, and take advantage of, the IEA Technical Information Service (TIS).

## WORK

TIS, which makes available a collection of technical information on all aspects of coal production and utilization, provides a powerful supplement to CANMET Technology Information Division's energy and mining information facilities and services.

A computerized data base established in 1977-78 provides both a source for retrospective searching and a means of disseminating this information through a computer-set monthly abstract journal, known as the "Coal Abstracts". Complimentary subscriptions are made available to interested parties throughout Canada.

Seven technical reviews have been issued "Underground Transport in Coal Mines", "Carbon Dioxide and the 'Greenhouse' Effect", "Combustion of Low grade Coal", "Methane Prediction in Coal Mines", "Hot Gas Cleanup", "Trace Elements from Coal Combustion" and "Underground Coal Gasification - Reaction Zone Mapping". Drafts of eight more technical reviews are almost complete.

TIS goals include the following:

- Improvement of data input; i.e. certain National Coal Board reports. These will be available on microfiche;
- Completion of Coal Thesaurus;
- Increase in size of Coal Abstracts;
- Preparation of Macro profiles;
- Provision of SDI service (selective dissemination of information);
- Expansion of enquiry response services;
- Preparation of an annual world directory of research in coal technology;
- Preparation of technical reviews;
- On-line access to data base.

Funds: On-going activity. Total funding commitment of \$45,000.

Subprogram: Dr. D.A. Reeve, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4060

1978-80

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Participation in IEA Activities (Sheet 4 - IEA Mining Technology)

#### OBJECTIVE

To support Canada's role in the IEA Mining Technology Clearing House (MTCH).

#### WORK

The objective of this IEA Agreement is to provide for contracting parties a central collection, collation and distribution centre for the dissemination of information on research and development projects relating to underground and surface coal mining and coal preparation technology.

Fifteen project registers have been compiled for publication in 1979. These registers give basic descriptions of research and development projects and cover a wide range of activities from prospecting to beneficiation.

The service also carries out technical investigations, three of which have been completed; hydrotransport of solids underground, trackless transport of men and materials underground, and mining methods to improve reserve recovery. Subjects now under investigation are strata consolidation, mobile power sources, optimization of equipment for use underground.

Following a meeting of experts held in Pittsburgh in August 1979, a shared-task project in the field of hydrotransport has been accepted by the executive committee. Of the four tasks agreed upon, Canada will be the lead country of two with the United States leading the other two.

Funds: On-going activity - total commitment \$25,000.

Subprogram Director: Dr. D.A. Reeve, Canada Centre for Mineral and Energy Technology,  
Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1. 613-995-4060

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Participation in IEA Activities (Sheet 5 - Control of NO<sub>x</sub> Emissions during Coal Combustion)

#### OBJECTIVE

To support Canada's role in the establishment of a project on control of NO<sub>x</sub> during coal combustion.

#### WORK

The planned work covers the pretesting or screening of approximately 15 coals of non-U.S. origin in the Environmental Protection Agency Small Scale Screening Furnace to evaluate the performance of coals of widely differing characteristics in a facility "Low NO<sub>x</sub> Burner", especially designed to minimize nitrogen oxides emissions during combustion.

Arrangements have been made to supply 7 Canadian coals from Nova Scotia (1), Ontario (1 blend), Saskatchewan (2), Alberta (2), and British Columbia (1) for the screening trials. Screening test completion is projected for January 1981 and large scale testing start and completion, April and November 1981, respectively. It is anticipated that the follow-up to the test program will include a documented assessment of the low NO<sub>x</sub> burner technology in a P.F. fired boiler unit in Canada.

Funds: Total funding will be approximately \$46,000.

Subprogram W. A. Warfe, Environmental Protection Service, Department of the  
Director: Environment, Place Vincent Massey, Hull, Quebec K1A 1C8, 613-997-2342.

1978-80

Task: Fossil Fuels  
Program: Coal Supply  
Subprogram: Materials for Coal Production

#### OBJECTIVE

To solve major materials problems in coal washing facilities and introduce a materials awareness to the industry.

#### WORK

The large increase in projected tonnage of coal mined together with the further necessity for coal preparation will depend to some extent on handling and preparation costs. A recent survey of materials problems in coal washing throughout Canada indicated not only a multitude of maintenance problems due to wear but also a lack of knowledge with respect to solving these problems. The current R&D will contribute to solving the major materials problems in coal washing facilities and, by technology transfer, introduce a materials awareness. It is anticipated that a similar approach will be adopted for materials problems in the coal mining industry, with particular emphasis on the incendiarity of mining machine cutters.

During 1978-79 equipment was constructed to analyse erosion/corrosion metal wastage under materials/environment conditions simulating those identified by a national survey of material problems in coal washing plants as requiring attention.

In 1979-80 work included the evaluation, under conditions simulating those in coal washing plants, the resistance to erosion/corrosion of four materials typical of the range of materials and coatings in service in component units in coal washing plants. Benefits obtainable by two potential methods of corrosion control were determined.

In 1980-81, the generated data will be distributed to the industry, with specific recommendations for materials selection and corrosion control.

78-79 Funds: \$2,400

79-80 Funds: \$35,000

Subprogram Dr. R. Thomson, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth St., Ottawa,  
Ontario, K1A 0G1 613-995-4044.

1978-80

Task: Fossil Fuels  
Program: Coal Combustion  
Subprogram: Conventional Technology

## OBJECTIVE

The objectives are:

- to use low grade coals for replacement of premium coals, oil or natural gas, in both industrial and utility applications;
- to use previously rejected coal products; and
- to develop improved combustion techniques for coals, including control of combustion products.

## WORK

Below are listed projects which have been completed in the past few years or are still in progress.

- Evaluations of combustion characteristics of Obed Marsh coal, Luscar coal, and oil sand's char have been completed.
- Combustion and design criteria for the use of Hat Creek coal in a thermal generating plant have been assessed.
- In conjunction with B.C. Hydro, field trials of Hat Creek coal for power generation have been undertaken.
- Modifications to the EMR tunnel furnace have been completed.
- Evaluations of three conditioning agents and of coal blends as conditioning agents or techniques for up-grading electrostatic precipitator performance have been completed.
- A program consisting primarily of contract work, is underway in cooperation with NRC and NBEPC to determine the technical and economic feasibility of coal-oil mixture (C-O-M) firing for utility boilers and for blast furnace operations.
- Combustion performance of fine coal reject has provided justification for industrial demonstration and a burn trial using Great Canadian Oil Sands by-product coke has shown that it can be burnt but that catalysts are ineffective.
- Studies relating to utility use of low grade coals include ignition and combustion characteristics of two high sodium-lignites with limestone slug additions; a joint program with Ontario Hydro which established blending of specific coals as a means of meeting sulphur oxide and fly ash emulsion guidelines; and installation of coal handling and drying equipment for the new pilot scale boiler yet to be installed are underway.
- Combustion of a mixture 10% coal-in-oil in tandem with the spherical agglomeration process was demonstrated in the NBEPC 10MW boiler. Detailed designs and economic assessment relating to STELCO's 3-tuyère trial on combustion of coal-in-oil mixtures have been completed.

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Task: Fossil Fuels  
Program: Coal Combustion  
Subprogram: Conventional Technology

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- Contract work relating to spherical agglomeration and to bench scale stabilization of coal-oil mixtures; NBEPC trials on coal oil mixtures containing up to 33% coal and initiation of a mechanism to assess the economic viability of coal-in-oil combustion are almost completed.
- 8 trials on low grade coals and coal rejects providing characterizations of combustion performance, particulate and pollutant emissions have been completed.
- Design and commissioning of an experimental electrostatic precipitator for measurement of resistivity of particulates from western coals is underway.

78-79 Funds: \$250,000

79-80 Funds: \$260,000

Subprogram Director: Dr. R. Thomson, Canada Centre for Mineral and Energy Technology,  
Department of Energy, Mines and Resources, 555 Booth Street, Ottawa,  
Ontario, K1A 0G1. 613-995-4044

1978-80

Task: Fossil Fuels  
Program: Coal Combustion  
Subprogram: Developing Energy Technology

## OBJECTIVE

To develop fluidized bed technology for improved combustion efficiency and use of lower grade fuels which are discarded at present.

## WORK

The thrust of CANMET R&D is presently towards development of atmospheric fluidized-bed technology relating to the DND fluid bed heating plant at Summerside, PEI. This, and other projected proposals will contribute significantly to substitution of oil by coal, while, at the same time, satisfying DOE environmental requirements. It is important that the in-house supporting R&D effort be maintained in spite of the increased requirement for scientific authority responsibilities. Further demonstration plants for coal to electricity based on pressurized fluidized-bed combustion and gasification will demand additional effort on CANMET's part. A strategy for in-house R&D relating to gasification will be developed in recognition of proposed and projected coal to electricity demonstration plants.

Research conducted in 1978-79:

- operating characteristics of the pilot-scale fluid-bed combustor have been defined and fuel handling and exhaust gas systems installed.
- combustion characteristics of Hat Creek and Luscar coals have been determined.
- an efficiency evaluation of a fluidized bed combustor fired with wood waste was carried out.

Through the in-house R&D program, combustion trials of 5 Canadian coals, including Minto coal with and without limestone additions, have been completed in the pilot-scale fluidized bed reactor. Differential temperature probes for bed characterization were installed in the reactor. Design of the larger more flexible reactor is almost complete.

Research conducted in 1979-80 includes:

- Completion of pilot fluid-bed combustion trials on 4 western and 2 eastern coals including evaluation of sulphur capture from Minto Coal.
- Initiation of contract to support construction and commissioning of a pilot FB combustor outside EMR for scientific studies on sulphur capture.
- Construction and instrumentation of an improved and more flexible pilot FB combustor. Promotion of interest for cooperative CANMET/industry project to implement fluidized-bed combustion of coal washery rejects, as opposed to marketable coal, for coal drying by discussions with companies such as Luscar, Union Oil and Kaiser.

78-79 Funds: \$400,000

79-80 Funds: \$525,000

Subprogram Director: Dr. R. Thomson, Canada Centre for Mineral and Energy Technology,  
Department of Energy, Mines and Resources, 555 Booth Street, Ottawa,  
Ontario, K1A 0G1. 613-995-4044

Task: Fossil Fuels  
Program: Coal Combustion  
Subprogram: Materials for Fluidized-Bed Combustion

#### OBJECTIVE

To document the materials degradation mechanisms of corrosion and erosion in fluid bed combustors in order to optimize materials selection and design parameters for atmospheric and pressurized fluid beds.

#### WORK

Materials R&D in 1979-80 has been restricted to a contracted study to investigate performances of heat exchanger tubing and ancillary equipment for low pressure steam fluidized-bed boilers. To date, techniques have been established to examine the corrosion/erosion resistance of coal washing plant materials. In the coming year, the effects of typical coal washing plant process variables on corrosion/erosion of four generic types of materials will be determined. The contracted fluidized-bed materials study has in the past year provided a literature survey of materials R&D and performance related to fluidized-bed applications. The pilot combustor has now been modified for the test program to be conducted in 1980-81. The combustion trials will be conducted under conditions simulating those expected for the CFB Summerside fluidized-bed heating plant and four generic classes of materials will be tested. It is also anticipated that an in-house effort will be placed on development and initiation of a study to determine materials performance applicable to high pressure steam fluidized bed boilers burning high sulphur Maritime coal and coal rejects.

78-79 Funds: \$6,000

79-80 Funds: \$214,000

Subprogram Dr. R. Thomson, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy, Mines and Resources, 555 Booth Street, Ottawa,  
Ontario, K1A 0G1. 613-995-4044

1978-80

Task: Fossil Fuels  
Program: Coal Combustion  
Subprogram: Demonstrations - New Coal Technologies

## OBJECTIVE

To promote institutional and industrial awareness and acceptance of fluidized-bed technology.

## WORK

Subsequent to identification of the need to replace the heating plant at Canadian Forces Base, Summerside, P.E.I., it was agreed that, while a packaged oil burning boiler was the cheapest immediate solution, a coal burning atmospheric fluidized bed heating plant was of greater mutual advantage to the user DND and the research authority EMR. Following conceptual and detailed design studies, construction will take place of one 40,000 lb steam/hr boiler on which trials will be conducted prior to construction of a second similar boiler.

The proposed heating plant replacement has provided EMR with an opportunity to demonstrate coal-fired fluid-bed technology. While providing this, the first stage in promoting institutional and industrial acceptance of fluid-bed technology, the project fulfills a major role in the implementation of energy strategies calling for substitution of coal for oil in steam raising and power generation. The conceptual plant and boiler designs are now complete. Detailed design of the boiler system will be completed in 1980, and construction of the plant is expected to start in 1981.

Future developments in technology demonstration will include a cooperative program with a coal producer to utilize colliery wastes in a fluid bed coal dryer; and sponsorship of an industrial scale (200,000 lbs/hr) boiler using atmospheric fluid bed technology.

78-79 Funds: \$462,000

79-80 Funds: \$1,038,000

Subprogram Director: Dr. R. Thomson, Canada Centre for Mineral and Energy Technology,  
Department of Energy, Mines and Resources, 555 Booth Street, Ottawa,  
Ontario, K1A 0G1. 613-995-4044

TASK 3  
NUCLEAR ENERGY



The objective of this Task is to support development of technology as necessary for the responsible application in Canada of nuclear energy, whether fission or fusion. The Task covers all aspects, from technologies necessary to ensure the fuel supply, through utilization, to waste management.

The large funding level of this Task, or more specifically of Program 3.3 Nuclear Energy Utilization and Support, reflects the historically strong federal support of the development of the CANDU reactor and associated systems. By contrast, other major energy sources have traditionally had strong private sector research and less need for federal support.

For convenience, both the regulation (3.1) and development (3.2, 3.3 and 3.4) aspects of nuclear energy appear listed in the same Task. In fact, they are administratively quite separate. Regulation is the responsibility of the Atomic Energy Control Board, while development is largely the responsibility of the Atomic Energy of Canada Ltd.

The ultimate goal of the Task is to support an alternative to the declining fossil fuel resource while ensuring that the alternative is safe and environmentally acceptable.

The Task Coordinator is:

Mr. J.A.L. Robertson  
Atomic Energy of Canada Ltd.  
Chalk River, Ontario, K0J 1J0  
613-687-5581

This Task is divided into four Programs:

### 3.1 Research and Development in Support of the Regulatory Function

Regulation of nuclear activities in Canada is carried out by the Atomic Energy Control Board. In support of this activity, the AECP supports research and development in fields of safeguards and security, health effects, environmental effects and risk and safety evaluation.

The Program Convenor is:

Mr. R.M. Duncan  
Atomic Energy Control Board  
Box 1046  
Ottawa, Ontario, K1P 5S9  
613-995-7651

### 3.2 Fuel Resource Base

This Program's long term objective is to ensure that all possible sources of nuclear fuel in Canada are known, and that the most effective exploration methods are used to find them. The Federal-Provincial Uranium Reconnaissance Program, managed by the Geological Survey of Canada, with the intention of delineating all potential uranium (and thorium) producing areas in Canada, was prematurely terminated commencing

March 31, 1979 as an economy measure. All outstanding data were publically released during 1979.

The Program Coordinator is:

Dr. A.G. Darnley  
Geological Survey of Canada  
Department of Energy, Mines and Resources  
601 Booth Street  
Ottawa, Ontario, K1A 0E8  
613-995-4909

### 3.3 Nuclear Energy Utilization and Support

Much of the following information on this Program is taken from "The AECL Research and Development Program" edited by R.G. Hart and A.D.B. Woods, Atomic Energy of Canada Limited, AECL Publication No. AECL-6781.

The federal government supports the development of nuclear power in Canada, through the Crown Corporation, AECL. This reflects the commitment of the federal government to the development and improvement of nuclear technology in anticipation of nuclear power meeting an increasing fraction of the demand for electricity.

The federal government, through AECL, has been the major participant in Canada's nuclear energy field. In this circumstance, R&D strategy has been devised by AECL to ensure availability to Canada of a nuclear technology as well as the means by which this technology may be transferred to the commercial and utility sector.

A description of AECL's R&D strategy is presented here only in the form of objectives of the major R&D areas.

For Power Reactor Systems (3.3.1 Sheets 1-13), the overall objective is to assure minimum initial and life-cycle costs of current and future reactor systems consistent with performance and safety standards. Work in this area is currently concentrated on CANDU-PHW support. Sub-objectives relate to fuel channels, out-reactor components, systems chemistry, thermohydraulics, reactor physics, control and instrumentation, and fuel performance. A further objective is to provide the other parts of the industry e.g., designers, operators, manufacturers, regulatory bodies with the science and technology they need to do their jobs properly, in a form they can easily use.

For the Advanced Fuel Cycle (3.3.2 Sheets 1-3), the objectives are to perform those research activities and assessment studies necessary to understand the technical and economic feasibility and the implications of the development and introduction of fuel-cycle alternatives. Using the natural-uranium cycle it is possible to recover only about 1% of the energy potentially available from uranium. However, advanced fuel cycles, using thorium in conjunction with either the plutonium produced in current CANDU reactors or enriched uranium, will allow that energy recovery to be increased many-fold. These advanced cycles make the cost of nuclear energy less sensitive to variations in the price of uranium and thorium, hence making feasible the use of low-grade ores and promising a secure supply of low-cost energy for centuries. Experimental

work is being carried out at the laboratory level and is concentrating on verification of the feasibility of the self-sufficient thorium cycle. Assessment work covers a broader spectrum, including slightly enriched once-through cycles and the non-proliferation aspects of all cycles. The recent focus for this work has been sound and effective Canadian input into INFCE which is now nearing completion.

For Environmental Protection and Radioactive Waste Management (3.3.3 Sheets 1-6), work is concentrated on radioactive-waste management and a quantification of the associated environmental and health hazards. The goals are to prove that reactor wastes and nuclear fuel wastes can be disposed of safely and to develop methodology that can be used to assess the environmental and health effects of nuclear and other waste products.

The key element is the development of a series of theoretically sound and experimentally verified computer programs which can be used to predict the release of radioactive material from a waste repository, its dilution (or concentration) in the environment, and its uptake by and effect on man.

The development of safeguards against nonpeaceful uses of CANDU technology is also included in this subprogram.

For Heavy Water Processes (3.3.4 Sheets 1-3), the overall objective is reliable and economic supply and management of heavy water. Specifically this work is concentrated on support for the operating Canadian heavy-water plants which use the Girdler Sulphide (GS) process and the application of the recently developed Hydrogen-Water Exchange (HWE) processes to heavy-water upgrading and tritium removal.

For Underlying and Advanced Systems Research (3.3.5 Sheets 1-4), the objective of the underlying and advanced-systems research program is to:

- support AECL's mission as presently defined
- be aware of and respond to developments elsewhere, and
- provide the basis for future progress.

In pursuit of these goals, AECL research laboratories carries out long-term programs in basic science aimed at better fundamental understanding of the processes involved in current and future nuclear-energy systems. These programs are in the areas of Biology, Chemistry, Materials Science, Physics and Advanced Systems. All of them address simultaneously the three basic goals described above, though the emphasis in any given area will shift to accommodate changing priorities in the components of AECL's mission and to respond to progress made, inside and outside AECL. Such progress, at the frontier of science, always includes unpredictable developments.

For New Applications (3.3.6), the goal is to assess, on a continuing basis, the economics and status of other energy options (nuclear and non-nuclear) so that AECL remains up-to-date on the competitive position of its current technology and is alert to new applications for it.

The funds applied to this Program are given on the following pages. These funds are exclusive of funds to operate the research establishments at which the R&D is conducted. The latter are being funded at the levels of \$57M (1978-79) and \$61.7M (1979-80).

The specific objectives of the elements of the research establishments, not classed as direct R&D, are:

- for Major Facilities, to operate those facilities which, for reasons of safety, diversity of use, continuity of operation or efficiency, require a formal operating organization.
- for Site Services, to provide the services and utilities essential to operation of the laboratories. The remote location of the laboratories makes necessary a high degree of self-sufficiency in functions which, in an urban setting, would be available from local utilities, public works and contractors.
- for Site Administration, to provide the administrative services required for efficient operation of the laboratories. Services include finance, accounting, purchasing, personnel, staff development, industrial relations, public relations.
- for Support Services, to provide support and services to the residential communities of Deep River, Ontario and Pinawa, Manitoba consistent with program requirements and corporate responsibility.

The Funds devoted to operating and servicing the research facilities used for other Tasks and Programs are not generally included in the Funds identified with those Tasks and Programs. Thus, the Funds shown for program 3.3 (Table 1 in the Introduction) are not directly comparable to those of the other Programs.

The Program Convenor is:

Mr. J.A.L. Robertson  
Atomic Energy of Canada Ltd.  
Chalk River, Ontario, K0J 1J0  
613-687-5581

### 3.4 Fusion

The growing nuclear fusion work is divided into inertial confinement (3.4.1), materials and engineering of fusion reactors (3.4.2) and magnetic confinement (3.4.3). This funding is not intended to support a major Canadian attack on this technology. Rather, it is to fund narrowly selected areas of high quality fusion research in order to contribute to the international fund of knowledge and, as a result, gain the access to the international effort and maintain an in-depth scientific awareness of the status and prospects for the development of fusion power.

The Program Coordinator is:

Dr. T.S Brown  
Division of Physics  
National Research Council  
Montreal Road  
Ottawa, Ontario, K1A 0R6  
613-993-0810



1978-80

Task: Nuclear Energy  
Program: Research and Development in Support of the Regulatory Function  
Subprogram: Research of the Atomic Energy Control Board (Sheet 1 - International Safeguards and Physical Security)

#### OBJECTIVE

- To install and demonstrate instrumented schemes by which Canadian designed reactors may be safeguarded, especially with respect to irradiated spent fuel.
- To investigate generic aspects of the physical security of nuclear facilities.

#### WORK

With respect to instrumented schemes:

- For a 600 MW reactor: establishing an instrumented scheme; designing, producing and installing seals and surveillance instruments; testing for a limited break-in period.
- Diversion path analysis of routes by which spent fuel could be removed from a station; for the 600 MW design and for the Bruce design.
- Assistance to the International Atomic Energy Agency in technical evaluations, in engineering feasibility studies, and in engineering design.
- Assistance to the International Atomic Energy Agency by the cost-free provision of expert manpower, and with the costs of travel related to this program.

With respect to generic aspects:

- Investigations of the strengths and weaknesses of various nuclear facilities and structures of the type used in nuclear facilities.

The funds below are for all of Subprogram 3.1.1

78-79 Funds: \$1,066,000

79-80 Funds: \$1,343,000

Subprogram Mr. R.M. Duncan, Atomic Energy Control Board, Box 1046, Ottawa, Ontario,  
Director: K1P 5S9: 613-995-7651.



1978-80

Task: Nuclear Energy  
Program: Research and Development in Support of the Regulatory Function  
Subprogram: Research of the Atomic Energy Control Board (Sheet 2 - Risk and Safety Evaluation)

#### OBJECTIVE

To assess the risk and evaluate the safety of licensable nuclear facilities.

#### WORK

The following areas are covered in the 1979-1980 program:

- Assessment of risks from external hazards
  - aircraft crash
  - floods
  - tornados
  - earthquake
- Investigation of system performance under accident conditions
  - containment under overpressure conditions
  - rewetting of hot fuel surfaces
  - seismic qualification of critical equipment
  - fuel channel behavior under loss of coolant conditions
- Failure analysis and in-service inspection
  - crack susceptibility of heavy water plant steels
  - relationship between inspection interval and failure risk
  - development of on-line crack growth monitors

For funding see 3.1.1 (Sheet 1)

Subprogram Mr. R.M. Duncan, Atomic Energy Control Board, Box 1046, Ottawa, Ontario,  
Director: K1P 5S9. 613-995-7651.

1978-80

Task: Nuclear Energy  
Program: Research and Development in Support of the Regulatory Function  
Subprogram: Research of the Atomic Energy Control Board (Sheet 3 - Health Effects)

## OBJECTIVE

To assist in developing and substantiating appropriate standards and to support capability to assess health effects on humans with respect to nuclear radiation. Note: research on conventional mine hazards such as rock instability are outside the scope of this Inventory.

## WORK

The following areas are covered:

- Personal dosimetry - assessment of the accuracy and overall suitability of a personal radon daughter and thoron daughter dosimeter for uranium miners.
- Instrumentation development - development of a simple dry radon gas calibration standard.
  - optimize shielding, counting and geometrical factors for a lung burden counter for uranium.
- Radioactive devices - investigation of physical condition of devices sent for disposal.
- Radiation protection training - conduct of Uranium Mine Inspectors Training Course.
  - investigation of all radiation protection training in Canada.
- Life Sciences - determination of feasibility of using bioassay and in-vivo measurements in uranium workers for dose calculations.
  - sputum cytology survey of uranium workers and controls.
  - mortality experience of miners exposed to radon and radon daughter products in the fluorspar mines of St. Lawrence, Newfoundland.

For funding see 3.1.1 (Sheet 1)

Subprogram Dr. H. Stocker, Atomic Energy Control Board, Box 1046, Ottawa, Ontario,  
Director: K1P 5S9. 613-995-7651.

1978-80

Task: Nuclear Energy  
Program: Research and Development in Support of the Regulatory Function  
Subprogram: Research of the Atomic Energy Control Board (Sheet 4 - Environmental Effects)

#### OBJECTIVE

To assist in developing and substantiating criteria and guidelines for environmental impact of radioactivity released from nuclear facilities including support of regulations governing management of nuclear wastes.

#### WORK

The following areas are covered:

- Studies of the geochemical retardation of radionuclides in representative unconsolidated Canadian geologic materials.
- Investigation of methods for the removal of radium from uranium mill tailing effluents.
- Assessment of the long term suitability of present and proposed methods for the management of uranium mill tailings.
- Assessment of techniques for immobilizing reprocessed radioactive wastes.

For funding see 3.1.1 (Sheet 1)

Subprogram Dr. J.R. Coady, Atomic Energy Control Board, Box 1046, Ottawa, Ontario,  
Director: K1P 5S9. 613-995-7651.

1978-80

Task: Nuclear Energy  
Program: Research and Development in Support of the Regulatory Function  
Subprogram: Research of the Atomic Energy Control Board (Sheet 5 - Regulations -  
Development and Impact Assessment)

#### OBJECTIVE

To assist in developing and substantiating new or modified regulations under the AECB Act and to develop the basis for socio-economic impact analysis of these regulations.

#### WORK

The following areas are covered:

- studies of the cost to society of the imposition of regulations on uses of nuclear energy.
- optimizing regulatory methods.

For funding see 3.1.1 (Sheet 1)

Subprogram Mr. M. Joyce, Atomic Energy Control Board, Box 1046, Ottawa, Ontario,  
Director: K1P 5S9. 613-995-7651.

Task: Nuclear Energy  
Program: Fuel Resource Base  
Subprogram: Exploration R&D - NEA/IAEA International Collaboration Program

#### OBJECTIVE

The short term objective of the program is to ensure that all areas in Canada which may contain uranium resources are publicly identified and delineated, so as to facilitate the discovery of deposits by industry and assessment of resources by government.

The long term objective is to maximize the amount of nuclear raw materials available for future use or sale by Canada by minimizing the overall national costs in finding new resources through increasing the effectiveness of exploration methods.

A third objective is participation in NEA/IAEA collaborative projects.

#### WORK

Attainment of the short term objective has been by means of the Federal-Provincial Uranium Reconnaissance Program (URP). Some work has been performed in all provinces and territories of Canada. Federal-provincial agreements were current in 1978-79 with Newfoundland, Ontario, Manitoba, Saskatchewan and British Columbia. The area of Canada covered to the end of 1977-78 totalled 2M km<sup>2</sup>. This work constituted Canada's contribution to the international Uranium Resource Evaluation Program of the Nuclear Energy Agency/International Atomic Energy Agency (NEA/IAEA). For reasons of economy, federal expenditures for the Uranium Reconnaissance Program have been terminated as of March 31, 1979. It is expected that work will continue in various provinces with provincial funding and federal advisory services.

Projects to meet long term objectives have been going through the planning stage, and involve Canadian participation in various international collaborative research projects to be coordinated through the NEA/IAEA.

#### Projects include:

- URP Airborne gamma-ray spectrometry surveys using high sensitivity equipment, and
- URP National Geochemical Reconnaissance
- URP Airborne magnetic gradiometer surveys
- Follow-up studies to assess the effectiveness of URP surveys.
- Construction of radiometric field calibration facilities
- Development of airborne and borehole instrumentation.

78-79 Funds: \$4,205,000

79-80 Funds: \$2,447,000

Subprogram Dr. A.G. Darnley, Geological Survey of Canada, Department of Energy,  
Director: Mines and Resources, 601 Booth Street, Ottawa, Ontario K1A 0E8.  
613-995-4909



Task: Nuclear Energy  
Program: Fuel Resource Base  
Subprogram: Reserve and Resource Assessment

#### OBJECTIVE

To provide technical backup and improvements to the reserve and resource assessment activities.

#### WORK

At the GSC the Uranium Resource Evaluation Section will continue providing annual uranium and thorium resource estimates and information on uranium exploration for policy and regulatory decision. In addition, research is carried out on special metallogenic problems related to new geological environments.

At CANMET, the Mine Evaluation Group annually assesses Canada's reserves of uranium, including evaluating economic viability. Of necessity, this requires developing appropriate methodology; ongoing work includes developing geostatistical techniques for better prediction of orebody extent, mine cost models, and evaluation procedures.

79-80 Funds: \$530,000

80-81 Funds: \$644,000

Subprogram Director: Dr. A.G. Darnley, Geological Survey of Canada, Department of Energy,  
Mines and Resources, 601 Booth Street, Ottawa, Ontario K1A 0E8.  
613-995-4909

Task: Nuclear Energy  
Program: Fuel Resource Base  
Subprogram: Processing of Radioactive Ores

#### OBJECTIVE

To improve conventional and develop alternative technologies for maximizing uranium and by-product recoveries, as well as recovery for subsequent isolation of environmentally undesirable components (radionuclides and some metals).

#### WORK

Progress has been made previously in reducing the radium content of solid effluents and in improving bacterial leaching, ion exchange, solvent extraction and chlorination technologies. Conventional sulphuric acid leaching is being improved to reduce the radium content of solid effluents to less than 50 pCi/g with at least 95% uranium extraction. Alternative technology developments involving chlorination and/or hydrochloric acid leaching aim to recover 99% of uranium, 85% of thorium and, if applicable, 85% of arsenic, 95% of the nickel and 80% of the rare earths. These new technology developments also aim to produce tailings containing less than 20 pCi/g of radium and no sulphides.

Equipment optimization will be carried out to provide scale-up data for an economic assessment. Running a continuous, integrated circuit will provide solutions for purification of the metals and subsequent recovery as final saleable products. Radionuclides will also be in solution and will require to be isolated for safe disposal.

Longer Term plans include:

- further development and economic assessment of alternative extraction technology for low grade and complex ores involving chlorination and/or hydrochloric acid leaching
- method for isolation of radionuclides from chloride leach liquors optimization of the purification circuit (solvent extraction and ion exchange) to recover high-purity uranium from sulphuric acid processing leach liquors
- method for removal of thorium from conventional leach effluents.

78-79 Funds: \$600,000

80-81 Funds: \$600,000

Subprogram Dr. H. Sawatzky, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy Mines and Resources, 555 Booth Street, Ottawa,  
Ontario, K1A 0G1. 613-995-4053.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 1 - Fuel Channels Monitoring)

## OBJECTIVE

To monitor current fuel channels, or pressure tubes, before service as well as under in-service conditions.

## WORK

The on-going work includes inspection and assessment of the as-manufactured tubes, including critical crack length testing of irradiated and unirradiated specimens from different batches of tubes. Also being done is in-reactor measurement of the tube elongation, deflection and diametral creep. Effort in this area is expected to continue at about the current level for the foreseeable future.

The test program initiated in September 1974 to define the engineering parameters governing delayed hydrogen cracking in pressure tubes is giving results which generate confidence that pressure tubes can be installed and operated in reactors at stress concentration factors below those resulting in cracks and leaks. This is achieved through improved procedures for making the end-fitting to tube joints.

Collaboration continues with Ontario Hydro on the dimensional gauging of pressure tubes, and the interpretation of the results.

The ACCORD (Analysis of CANDU Core Deformation) model, for assessing the interaction of fuel channels and end-shields in CANDU reactors, has become a major tool for making decisions on the best operating procedures to adopt so that the maximum life can be obtained from the present Pickering and Bruce fuel channels. The supporting laboratory scale studies are providing evidence on the effects of tube-to-tube variation, end-loading, and basic parameters needed for the ACCORD program.

The funds below are for all of Subprogram 3.3.1

78-79 Funds: \$10,900,000

79-80 Funds: \$9,100,000

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 2 - Fuel Channels-Understanding Behaviour)

## OBJECTIVE

To predict the behaviour of fuel channels in power reactors over the operating life of the reactor.

## WORK

This work is concerned with the physical characteristics of pressure tubes as they undergo slow changes during their lifetime due to the effects of heat, gravity, pressure and irradiation. These changes must be accurately predicted and allowed for in the design, and AECL had developed, and continues to improve, computer codes which permit such predictions. These codes are based on fundamental information which has been developed via an intensive R&D program extending over a period of more than 20 years, and they are regularly checked against fuel-channel behaviour in the power stations.

Current emphasis in the R&D program in on:

- improved understanding of the effect of irradiation on dimensional changes
- the development of a new pressure-tube material with greater dimensional stability under irradiation
- improved end-fitting/pressure-tube joints
- the behaviour of pressure tubes under postulated-accident conditions
- the effects of deuterium on the mechanical properties of pressure tubes.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 3 - Fuel Channels - Components)

## OBJECTIVE

To gain the operational and economic advantages of greater uniformity in behaviour of pressure tubes and better lifetime or neutron economy; and to provide improved joints that will minimize local hydrogen absorption at tube ends, and to develop suitable methods for joining tubes of new alloys.

## WORK

The work on the pressure tubes themselves falls into two divisions:

- optimization of fabrication variables
- development of new alloys.

Laboratory scale studies in both areas are at the stage where the manufacture of sizeable trial batches of tubes is necessary to permit assessment of the various options. Tubes in XL alloy are available for use in in-reactor loops.

The work on joints also falls into two divisions:

- improvement of present joints
- joints for new alloys

Effort is concentrated on the improvement of present joints. It is hoped that a clear picture of the possibilities for improving present joints will emerge. The effort can be then switched to joints for new alloys, if the advanced pressure tube program has advanced to the stage of needing new transition joints.

For Funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.



1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 4 - Out-reactor Components - Quality Control Methods)

#### OBJECTIVE

To improve quality control methods in the manufacture of nuclear system components.

#### WORK

Nondestructive testing (NDT) methods have been developed and are now being used by industry in the manufacture of pressure tubes and in manufacture of steam generator tubing. Acoustic emission during rolling of pressure tube joints is being examined to determine if a quality control method can be developed. There is a continuing consultation with manufacturers and utilities on nondestructive testing methods and their use in the manufacture and inspection of components (e.g., valves, calandria vessels, steam generators, etc.). This consultation will be needed until a commercial consulting company with laboratory facilities can trouble-shoot to meet the special requirements of the nuclear industry.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 5 - Out-reactor Components - In-service Inspection Methods)

#### OBJECTIVE

To develop and improve in-service inspection methods of out-reactor components

#### WORK

CANDU operating experience to date has revealed no serious deterioration in steam generator tubes but wear and fretting has occurred in other types of heat exchangers. In cooperation with Ontario Hydro, AECL has developed methods to detect tube wear. By 1979 a fully automated, high-speed system was available for steam generator tubes and this system can be adapted for use on other types of heat exchangers.

The work now consists of the evaluation and development of non-destructive methods such as eddy-current and ultrasonic methods. These could be applied to in-reactor gauging of pressure tubes as well as in-situ inspection of steam-generator tubes.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 6 - Out-reactor Components - Steam  
Generators and Heat Exchangers)

#### OBJECTIVE

To improve technology for design, manufacture, operation and maintenance of steam generators and heat exchangers.

#### WORK

Flow-induced vibration is always present in heat exchange equipment. Work is being done to determine how much vibration can be tolerated so tube fretting will be acceptable and how equipment designs can be analyzed for vibration. Experiments associated with wear and fretting, thermohydraulics and vibration are used to verify the techniques used to design heat exchange equipment.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 7 - Out-reactor Components - Other Process Components)

## OBJECTIVE

To improve technology for design, manufacture, operation and maintenance of out-reactor components except for steam generators and heat exchangers which are covered under 3.3.1 Sheet 6.

## WORK

Rotary pump seals have contributed to power station down-time mainly because in-service life is too short. Larger pumps have made seal design more difficult and lack of redundant pumps has increased the desired in-service life from two to five years. Periodic examinations of an AECL pump seal design, the best currently available, which is used in the Bruce A Generating Station have suggested an in-service life of only three years. The use of stress analysis has indicated that pressure and temperature variations may be responsible for reduced lifetime. Work continues.

Technology for design of live-loaded valve stem packings and mechanical joints to meet heavy water leakage specifications have been transferred to industry. A process for valve bellows has been developed in cooperation with industry. Bellows produced by this process have performance comparable with other commercially available bellows when using conventional materials, while extension to new materials, unsuited to present fabrication methods, offers promise of longer life.

Fuel handling equipment for the on-power refuelling of CANDU reactors and rotary pump seals use elastomer materials for seals. The resistance of these materials to the environment encountered in power reactors is being determined.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 8 - Systems Chemistry)

#### OBJECTIVE

- To develop methods for predicting the corrosion and activity transport behaviour of CANDU heat-transport systems for a range of chemistry conditions
- To define appropriate chemistry conditions to minimize corrosion and activity-transport problems
- To develop methods for removing radioactivity from the system, if the need arises.

#### WORK

The system chemistry of CANDU heat-transport systems is well understood; the chemistry conditions can be well controlled. A model that predicts the radiation fields on major system components due to activated corrosion products has recently been developed and is in good agreement with plant measurements. Work is continuing on the development of a similar model for predicting fission-product activity transport.

An effective heat-transport-system decontamination technique, CAN-DECON, has been developed for the CANDU system. The technique is superior to other methods since it requires a much shorter reactor shutdown and leaves a much smaller amount of waste material to be disposed of. The CAN-DECON technology is now being exploited commercially, under a licensing agreement, and has successfully been applied to an American boiling-light-water reactor system. Recent developments show that a modified form of the CAN-DECON treatment gives much larger decontamination factors for austenitic steels than those obtained with other viable methods.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.



1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 9 - Thermalhydraulics - Heat Removal in Normal Operation)

## OBJECTIVE

To determine the critical heat flux in an operating fuel channel in order to provide the experimental and theoretical backup needed to design CANDU fuel and define operating procedures to ensure that maximum power is achieved.

## WORK

Work includes:

- experimental measurements on a full-size electrically heated, water-cooled channel. At present there is little prospect of a mathematical simulation of the critical-heat-flux (CHF) problem so it must be handled by full-scale instrumentation.
- completion of fundamentally oriented experiments to study post-dryout behaviour (where CHF has been exceeded) on simple tubes.
- the development of new fuel designs (for example, specially designed grid plates) to yield higher critical powers.
- CHF experiments with Freon as the working fluid are being considered; Freon can be used at considerably less cost as compared to water. Criteria for scaling CHF data obtained in Freon to equivalent water conditions are being developed.
- the development of a theoretically based CHF analysis, referred to as a subchannel analysis, of two-phase flow and heat transfer in horizontal rod bundle. Work on a new subchannel analysis code, designed specifically for horizontal channels, is currently in progress.
- plans include measurements on a channel with a cosine axial heat distribution and experiments to assess dryout and post-dryout behaviour.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 10 - Thermohydraulics - Loss-of-coolant Safety Aspects)

## OBJECTIVE

To provide the experimental and theoretical backup necessary to ensure that CANDU reactors continue to meet the requirements of safety under postulated accident conditions as designs evolve. Specifically,

- to determine the behaviour of the system during a loss-of-coolant accident (LOCA); a wide range of break sizes and locations must be handled
- to determine the behaviour of the system during a loss-of-coolant and loss-of-emergency-coolant accident (LOEC).

## WORK

Work involves the development and verification of calculation procedures to assess:

- Thermalhydraulic performance of process and protective systems during a postulated LOCA. An improved code (RAMA), being developed, involves:
  - mathematical models for vapour liquid flows in ducts, ranging from homogeneous thermal equilibrium flow (vapour and liquid are assumed to have equal velocity and temperature) to separated thermal non-equilibrium flow (vapour and liquid are assumed to flow with different velocity and temperature),
  - computationally fast and accurate numerical solution procedures for these mathematical models when applied to complex pipe networks, and
  - models for components such as pumps, flow distribution headers, boilers and fuel channels.
- Fuel-to-moderator heat transfer and fuel channel mechanical behaviour during a postulated LOEC. The analysis involves the following computer codes:
  - CHAN for analysis of the fuel-to-moderator heat transfer, and
  - CREEPSAG for analysis of the mechanical behaviour of the fuel channel up to the point of first contact between the pressure tube and calandria tube.
- containment system performance during both LOCA and LOEC. This involves the development of improved models for zirconium/water reactions in the channel, ballooning of the pressure tube to contact the calandria tube, transfer of heat from the channel to the moderator, pressure transients in the containment (including hydrogen combustion) and rate of fission-product deposition in the containment.

Existing calculation procedures consist primarily of empirical models which cannot be applied outside their range of validity. AECL's approach is to establish a sound theoretical basis for these calculations and verify them systematically against

(continued on next page)

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 10 - Thermohydraulics - Loss-of-coolant  
Safety Aspects)

(continued from previous page)

experiments of gradually increasing scale. The end product will be a system of computer codes for analysis of hypothetical reactor accidents which has been checked for theoretical soundness and verified against experiments at different scales. It is estimated that this program will be completed in 1984.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 11 - Reactor Physics)

## OBJECTIVE

The objectives may be summarized as:

To develop computer codes that accurately predict the performance of CANDU reactors during equilibrium and transient operation, and that allow assessment of the CANDU options vis-à-vis other energy options. More specifically, the objectives are:

- To perform reactor physics experiments to verify the analytical methods used in the design of reactors.
- To develop and improve reactor physics computer codes.
- To have the ability to assess, in economic terms, changes in CANDU-PHW plant design, vis-à-vis other CANDU concepts.

## WORK

Work includes reactor physics experiments at the ZED-2 test facility at Chalk River.

Until recently the emphasis in reactor-physics code development has been on the prediction of reactor performance during steady-state operation, i.e. reactivity balance and fuel burnup/management. Further, the codes have been verified mainly against clean (i.e., zero burnup), cold (i.e., room-temperature) experiments carried out in the ZED-2 lattice test facility.

The emphasis has now shifted to the prediction of behaviour during transient conditions (e.g., load following) and to verification of the codes with experiments which more closely approximate power-reactor conditions. The ZED-2 test facility has been modified so that it can operate with poisoned moderator, and experiments can be done with heated coolant.

It is important to continue to assess, on an economic basis, the relative position of the CANDU-PHW system vis-à-vis alternative systems, both nuclear and non-nuclear. Further development of the reactor economic and performance assessment code (called BLEEPSYS) is planned to keep the economic assessment up-to-date.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 12 - Control and Instrumentation)

## OBJECTIVE

To develop advanced control and safety system, reactor and process monitoring systems, instruments for R&D programs; and to investigate and develop computer and data communications networks for nuclear plants.

## WORK

Design and development is in the following areas:

- Dynamic simulations of major components of a large CANDU-PHW power plant for control/safety system studies.
- Improved regional overpower protective system for CANDU reactors.
- New control system for the NRU research reactor, using modern control techniques and new electronic hardware configurations.
- In-core flux-detector assembly for CANDU reactors, which will permit on-power replacement and in-situ calibration of individual detectors (a joint program with Ontario Hydro).
- Feeder-scanning technique for locating failed fuel in the power reactors.
- Instrumentation system to monitor the  $^{10}\text{B}$  content of a  $\text{D}_2\text{O}$  moderator.
- On-line heavy water ( $\text{D}_2\text{O}$ ) monitoring systems to detect  $\text{D}_2\text{O}$  leakage from the power reactors.
- Transducers and instruments in support of R&D programs.

Computer control work emphasizes the following areas:

- Modern multivariable control methods, which are capable of allowing for subsystem interaction, are being investigated, as these would provide a control system which should be more tolerant to plant upsets and hence avoid unnecessary shut-downs.
- Present CANDU power stations use centralized computers for control. Recent advances in electronics technology indicate that distributed computer systems could be more efficient and reliable, as they tend to locate the intelligence where it is required. Another advantage of this approach would be a significant reduction in cabling costs for the plant. The concept is being evaluated at CRNL, via the REDNET and INTRAN projects.
- The application of advanced techniques, e.g. automated text editing and computer-aided design.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.



1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Power Reactor Systems (Sheet 13 - Fuel Performance)

#### OBJECTIVE

To predict the behaviour of natural-uranium power reactor fuel under current operating and postulated-accident conditions, using theoretically sound and experimentally verified models.

#### WORK

While fuel-operating performance has been excellent, an improved capability to predict power-cycling behaviour will be required when the stations have to load-follow. Further work continues on modifications to the fuel which could improve power-cycling performance. Demonstration tests of improved coatings are planned for irradiation in the Bruce Generating Station: 1000 bundles of a modified graphite coating and 200 bundles with a siloxane coating.

The work on fuel behaviour under postulated-accident conditions is moving from the development of unidimensional models to the development of multidimensional models. The latter should be more accurate and thus their use could reduce the degree of conservatism in design while maintaining the required level of safety.

For funding see 3.3.1 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Advanced Fuel Cycles (Sheet 1 - Fuel Development)

## OBJECTIVE

The objectives are:

- to demonstrate irradiation behaviour of recycle fuels; to model the behaviour of recycle fuels;
- to develop glove box technology for the fabrication of alpha active pellet fuel;
- to complete detailed design of a small fabrication plant (100 Mg/a) using glove-box technology;
- to develop technology for remote fabrication of alpha active pellet fuel;
- to examine remote fuel fabrication routes other than the conventional sintered pellet route;
- to undertake irradiation development and evaluation of novel fuels; to set up generic support services common to Pu and  $^{233}\text{U}$  fuel development and production activities; to procure thorium based recycle fuel for experimental purposes; to identify feasible routes for the extraction of reactor grade thorium powder from Canadian resources.

## WORK

A laboratory pilot line has been constructed at CRNL for the fabrication of  $(\text{U,Pu})\text{O}_2$  fuel by cold pressing and sintering of pellets. Cold commissioning has been completed and Pu was introduced in August 1978. Fabrication and irradiation experience was gained by manufacture of 15  $(\text{U,Pu})\text{O}_2$  bundles. This will be followed by an extended campaign to manufacture  $(\text{Th,Pu})\text{O}_2$  fuel for experimental reactor physics purposes. A proposal is being prepared for a four year program to engineer a production line to gain experience in modifying full size equipment for use in glove boxes and to develop materials handling technology. This would facilitate commitment of a demonstration plant to manufacture  $(\text{U,Pu})\text{O}_2$  and  $(\text{Th,Pu})\text{O}_2$  fuel.

Work on the alternative fabrication routes has started and the feasibility of three routes has been demonstrated. These will be reviewed at intervals to select the most promising route.

$^{233}\text{U}$  brings a special problem, since the very high gamma fields necessitate heavy shielding. The first stage is a conceptual design study started in 1977 to define the requirements of a fabrication facility.

A number of irradiation tests have been proposed with  $\text{ThO}_2$  fuels enriched with  $^{235}\text{U}$  to provide information on the behaviour of this fuel.

The funds below are for all of Subprogram 3.3.2

78-79 Funds: \$6,800,000

79-80 Funds: \$6,200,000

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Advanced Fuel Cycles (Sheet 2 - Separations Technology)

#### OBJECTIVE

To develop and demonstrate in Canada the separation of wastes and recovery of useful fuel materials from CANDU fuels. Major emphasis is on thorium fuels but the treatment of natural uranium fuels is also covered. The waste treatment program will develop and demonstrate the necessary technology for waste immobilization.

Secondary objectives are to produce enough fissile and fertile material for fuel fabrication, development and reactor physics experiments; also to produce high-level wastes for demonstration disposal.

#### WORK

Gathering of basic data for reprocessing of thorium fuels and production of wastes for solidification will continue at WNRE. Laboratory scale experiments are being done in the existing WNRE hot cells.

The major facilities in the proposed program would be a pilot plant and eventually a demonstration plant with a capacity of 300 Megagrams heavy element per annum (MgH.E./a). The demonstration plant is sized such that scale-up would be possible both in terms of feasibility and cost. It is considered prudent to advance to this scale of demonstration in order to gather the data required (mainly costs, emissions and safeguards) and to demonstrate feasibility at the industrial level.

The pilot plant is planned to have a capacity equivalent to 10 kg Th/day. Design of a demonstration plant with a capacity of 1 Mg/day would be required during the 1980's.

For funding see 3.3.2 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Advanced Fuel Cycles (Sheet 3 - Reactor Physics and Assessment)

## OBJECTIVE

To acquire the reactor-physics data and methods required to assess the utilization of recycle fuels in CANDU reactors and to make those assessments.

## WORK

Most Canadian reactor-physics codes were developed for the natural-uranium fuel cycle and they must now be upgraded to handle other nuclides (e.g., Th-232, U-233, Pu-239, and mixtures thereof) used in the advanced fuel cycles. This upgrading involves the acquisition of the relevant nuclear data, the development of new calculational methods and the implementation of physics experiments to validate the codes. The experimental program will involve lattice experiments with unirradiated (Pu,U)O<sub>2</sub>, (Pu,Th)O<sub>2</sub>, and (U-233,Th)O<sub>2</sub> fuel-management schemes also need to be developed to handle the larger power peaking associated with enriched fuel. Other work includes criticality studies required for the handling and storage of enriched fuel, and nuclide production and shielding calculations for fuel reprocessing, fabrication, and disposal activities.

For funding see 3.3.2 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Environmental Protection and Radioactive Waste Management (Sheet 1 -  
Radioactive Waste Management - Reactor Wastes Management)

#### OBJECTIVE

To demonstrate that radioactive wastes arising from reactor operation (i.e., those not associated with used fuel) can be converted to a stable leach-resistant form which will immobilize the radionuclides in the waste repository.

In the short term, emphasis is focussing on the conversion of wastes to a stable form which has improved characteristics for interim storage and properties adequate for final disposal. Another short term objective is the selection of the most promising location and method of disposal on the converted wastes.

The medium term objectives will centre on the demonstration that the chosen waste form and disposal method are suitable for the permanent isolation of the waste.

#### WORK

The major facility for this development is the Waste Treatment Centre (WTC), being built at CRNL, which will be used to investigate reverse osmosis, evaporation, incineration, and bitumenization processes.

Liquid wastes will be concentrated by reverse osmosis and evaporation. The experience gained in laboratory-scale demonstrations will be factored into the design of the reverse-osmosis system for the WTC. The reverse-osmosis installation will be a batch system with two stages of concentration. The need for an evaporator to further concentrate the liquid wastes before bitumenization is still being assessed. Some evaporator testing will also be carried out.

The incinerator program is aimed at identifying the limitations of the current designs and the modifications required to obtain reliable processing of all combustible reactor wastes.

Several types of wastes are to be incorporated in bitumen with the main feeds being incinerator ash and the concentrated aqueous wastes. Tests to bitumenize these different feeds are being carried out in a twin-screw extruder-evaporator and in a wiped-film evaporator.

The funds below are for all of Subprogram 3.3.3

78-79 Funds: \$9,300,000

79-80 Funds: \$11,200,000

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.



1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Environmental Protection and Radioactive Waste Management (Sheet 2 -  
Radioactive Waste Management - Fuel Cycle Waste Management-Fuel  
Immobilization)

## OBJECTIVE

To develop the technology for:

- safely and economically storing the spent fuel until it is either reprocessed or sent to disposal
- immobilizing the spent-fuel wastes, either as unseparated spent fuel or as separated wastes, in a leach-resistant matrix
- safely and economically isolating the immobilized wastes from the biosphere for their hazardous lifetime.

## WORK

Work on interim storage is now primarily concentrated on dry-storage techniques which could, if necessary, be used in place of water-filled bays. Fuel from the WR-1 reactor is, after an initial decay period, stored in concrete canisters, the performance of which is routinely monitored to check design predictions. Some work is also being done on the corrosion rate of zirconium in storage-bay water.

Work on immobilization of unseparated spent fuel is concentrated on the development of two alternative systems: a simple containment system that would be expected to provide immobilization for 300 to 500 years while most of the radioactivity decays, and an advanced system that would provide immobilization for a much longer period and would be available as a back-up if analysis shows it is needed. One possibility being investigated for the advanced system is encasement of the fuel bundle in the lead matrix.

Work on immobilization of separated wastes is concentrated on the fixation of nonvolatile high-level waste fission products and actinides in glass and other ceramics. Of particular interest are the effects of temperature, water and radiation on the properties of glasses into which wastes may be incorporated. Heat, water and radiation all contribute to devitrification of glass and the conditions for devitrification must be well understood if glass is going to be used.

Conceptual designs of fuel and waste-immobilization pilot plants are being developed for costing purposes.

For funding see 3.3.3 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Environmental Protection and Radioactive Waste Management (Sheet 3 -  
Radioactive Waste Management - Fuel Storage and Disposal)

#### OBJECTIVE

The objectives are:

- to continue demonstrations of canister storage (begun with a small demonstration of an air-cooled concept - the concrete canister)
- to verify the concept of deep underground disposal in hard rock within 3 years.

#### WORK

Work on disposal is concentrated on determining the geophysical, geochemical and hydrogeological properties of various types of plutons (a type of rock formation found in abundance in the Canadian Shield) to determine their suitability for waste disposal. Attempts are being made to correlate surface features with underground features so that the properties of the formation can be reasonably predicted from surface observations. The program has involved, and will continue to involve, extensive drilling at CRNL, WNRE and other sites. Information on water chemistry, water flows, and radionuclide sorption on the rock surface is essential input into "pathway analyses" which will be used to assess the suitability of the formation for waste disposal. Extensive work is also being done on conceptual repository design and on the mechanical and thermal properties of the rock, knowledge of which is a necessary input to the design.

The canister development work is almost complete, and a summary report has been issued. Long term canister testing and demonstration will be accomplished by storing irradiated fuel from WR-1 in canisters in the WNRE waste management area, and routinely monitoring their performance. A scheme has been set up to monitor the behaviour of irradiated fuel in dry storage. A parallel scheme for assessing the behaviour of fuel stored in pools has been set up at CRNL. Selected fuel pins will be removed from storage and inspected thoroughly.

For funding see 3.3.3 Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Environmental Protection and Radioactive Waste Management (Sheet 4 -  
Protection of Man and the Environment - Environmental Research)

## OBJECTIVE

To develop and test methods for predicting the migration of radioactive nuclides and other waste materials from the waste repository (see 3.3.3 Sheet 3) through the geosphere to the biosphere.

## WORK

Major activities are:

- "Pathway analysis", taking into account ground-water movement, container and waste-matrix corrosion, sorption and desorption of materials on rock surfaces and dilution and concentration in the biosphere. This work also considers potentially disruptive phenomena such as earthquakes or ice ages. The analysis and methodology will be refined as information becomes available from the experimental program.
- Modelling and assessment for specific facilities and sites.

These activities are tied closely to the program to develop a repository for deep underground disposal.

For funding see 3.3.3 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Environmental Protection and Radioactive Waste Management (Sheet 5 -  
Protection of Man and the Environment - Biology Research)

#### OBJECTIVE

To carry out basic and applied research on the effects of radiation exposure on man and his environment.

#### WORK

Studies are being done on the irradiation effects in plants, animals and man.

The environmental and health effects of a nuclear waste repository and its ancillary facilities during the preclosure phase are being assessed.

Specifically, the work falls under the categories of

- Radiobiology; radiation biochemistry and virus research; and basic research on radiation induced changes.
- Waste heat; and application of nuclear methods to environmental problems.
- Dosimetry.
- Radiation hazards to humans; and population studies.
- Field irradiator gamma project; ZEUS project (effects of chronic low-level gamma radiation on a population of small mammals; and varying dose rates.

For funding see 3.3.3 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Environmental Protection and Radioactive Waste Management (Sheet 6 -  
Radioactive Waste Management - Safeguard Systems)

#### OBJECTIVE

Safeguards systems are being developed to:

- provide assurance that CANDU reactors that have been exported from Canada can be adequately safeguarded by the IAEA and are being used for peaceful purposes,
- assist the IAEA to apply safeguards to the reactors and other nuclear facilities in Canada so that they can provide international assurance that these facilities are not being used for a military program.

#### WORK

The IAEA Safeguards System for 600 MW CANDU reactors combines inspection with unattended surveillance, unit bundle accounting, and tamper-proof seals to detect and deter used-fuel diversion. To meet this requirement a used-fuel bundle counter is being developed with the specific function of determining the total number of irradiated bundles transported into the fuel bay through normal entry ports. The design of the bundle counter will incorporate features which could be applicable to other unattended safeguards instruments. Prototype used-fuel bundle counters have been constructed and these will be undergoing IAEA acceptance tests.

Developments of a safeguards approach for other power reactors in Canada, such as Pickering and Bruce, is also in progress. Further work on safeguards for the research reactors and their fuel-storage facilities will follow.

For funding see 3.3.3 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.



1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Heavy Water Processes (Sheet 1 - Girdler-Sulphide (GS) Process)

#### OBJECTIVE

To provide support for existing heavy water plants to help them in three key tasks: to ensure a reliable supply of heavy water, to reduce operating costs and ultimately to expand production.

#### WORK

Work falls within five categories:

- Materials: preconditioning of carbon steel surfaces as a means of reducing iron corrosion; stress corrosion cracking of stainless steels; heat exchanger tube materials; corrosion product deposition; prepare state-of-the-art manual on materials.
- Environmental safety: H<sub>2</sub>S-in-water monitors; evaluate performance of gas dispersal system; define combustion and explosive properties of H<sub>2</sub>S-air mixtures.
- Sieve tray performance: evaluate alternative antifoams; refine the model for sieve tray capacity and efficiency; optimize water chemistry to increase tray efficiency; define tray modifications; complete the Tray Manual.
- Process control: apply simulation programs; improve and extend process simulation models; develop dynamic simulation models to test by plant experiments; evaluate plant performance; methods to reduce energy consumption. Effort is now being focussed on heat economy.
- Chemistry: improve analysis for deuterium and for various process impurities; develop on-line analysis techniques; evaluate stability of antifoams; develop methods to control impurities causing foaming or depositions; Analytical Methods Manual and Process Chemistry Manual. The continuing assessment of antifoams has led to the selection of a single component agent which has been adopted by all plants and has significantly reduced the cost of antifoam chemicals.

The funds below are for all of Subprogram 3.3.4

78-79 Funds: \$3,865,000

79-80 Funds: \$1,800,000

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Heavy Water Processes (Sheet 2 - Alternative Heavy Water Processes)

## OBJECTIVE

To evaluate and develop alternative heavy water processes; this includes work on the Hydrogen-Water Exchange (HWE) processes and some fundamental research on chemical exchange.

## WORK

Work falls within three categories:

Process evaluation: expertise is maintained to examine new processes as they are and to re-examine old ones as conditions change.

Amine process: if prototype plant committed, further studies of catalyst stability, amine/catalyst solution purification, exchange rates, etc. Evaluation of plant materials.

HWE Processes: Continue to operate small on-line upgrading pilot unit and connect to research reactor (ZED-2) as demonstration; evaluate performance. A wet-proof catalyst has been developed. This promotes efficient hydrogen-isotope exchange between liquid and gaseous phases. A Canadian manufacturer for the catalyst has been selected and is under licence to AECL. Laboratory studies are currently directed toward improving catalyst performance and demonstrating processes and equipment in pilot plant studies.

For funding see 3.3.4 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Heavy Water Processes (Sheet 3 - Tritium Removal)

#### OBJECTIVE

The objective is to establish the technology for recovering tritium from CANDU reactor moderators and coolants. The removal of tritium from heavy water will probably be the first major application of the HWE process (reference 3.3.4 Sheet 2). It is planned to test this process, which will also require cryogenic technology, in a small pilot facility.

#### WORK

An assessment of candidates has led to the choice of a process based on the AECL wetproof catalyst to transfer D<sub>2</sub>-DT to the cryogenic distillation process. Demonstration has reached pilot plant stage.

Collaboration with industrial participants and Ontario Hydro in developing a Canadian technology for tritium recovery and the installation of the first plant at the Pickering Generating Station.

Work has also started on the technology for the storage and disposal of tritium.

For funding see 3.3.4 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

Task: Nuclear Energy  
Program: Nuclear Utilization and Support  
Subprogram: Underlying and Advanced Systems Research (Sheet 1 - Physics)

## OBJECTIVE

To maintain close contact with developments at the forefront of research in basic nuclear and related sciences and thereby to support AECL's applied programs with increase capability from prompt in-depth assessment and rapid response to significant advances.

## WORK

The main activities are:

- Studies of the structure of the nucleus
  - Research with the MP tandem accelerator and with the MP Tandem/Superconducting Cyclotron combination including use of beams of light and heavy ions for testing nuclear models, increasing understanding of reaction mechanisms and exploring new phenomena and new techniques in nuclear physics.
  - Experiments are being carried out at the MP tandem accelerator to test new methods of radioisotope dating, valuable in the determination of the age of ground water for the waste management program.
  - Determination of the neutron-capture cross section of zirconium-90.
  - "Classical" radioactivity research
  - Theoretical physics support of above.
- Studies of the property of condensed matter
  - Neutron scattering studies of dynamical behaviour of solids and liquids using slow neutrons.
  - Theoretical physics activities provide support and guidance to both the nuclear and condensed-matter experimental physics programs and support and consultation to other programs as required.
  - The development of solid-state nuclear radiation detectors.

The funds below are for all of Subprogram 3.3.5

78-79 Funds: \$8,918,000

79-80 Funds: \$9,200,000

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Underlying and Advanced System Research (Sheet 2 - Chemistry)

## OBJECTIVE

To maintain positions at the forefront of the relevant fields, through research of international stature, publications, participation at conferences and inter-laboratory staff exchanges, and thus provide the knowledge and awareness needed for future advances of the overall mission as well as underlying chemistry support for the fuel cycle, waste management and heavy water programs.

## WORK

Work is categorized as:

- Radiation Chemistry: The effects of photons, electrons, neutrons and heavy ions on chemical reactions, states of atomic and molecular excitation, and atomic and molecular structure. Particular attention is devoted to the solvated electron.
- Isotope Separation: Research on potential methods for separating isotopes, such as heterogeneous or homogeneous chemical exchange and laser photochemical excitation as required for heavy water processes, tritium removal, fission product purification, etc.
- Oxide Properties: The study of the properties of fission-product and actinide oxides. This is directed towards obtaining a basic understanding of the solubility and colloidal processes important in the transport of corrosion product and radioactivity in nuclear-power reactors, in the fabrication of advanced and recycled fuels, and in the treatment of radioactive wastes.
- Actinide and Fission-Product Chemistry: The preparation of a firm and broad foundation for the development of fuel-reprocessing and waste-management technology to forecast chemical equilibria in reprocessing plant solutions and in ground waters, the extrapolation of laboratory or pilot-plant data to plant conditions, the prediction of radionuclide migration underground, and in the future, the provision of scientific support and the awareness functions for advanced fuel cycles, generic waste-management research and spallation-target design activities.
- Properties of Fluid Interfaces: The assessment of the variation of solute partition in liquid-liquid contacting as a function of fuel-reprocessing operating conditions, and the importance of surface and interfacial properties in liquid droplet formation and stability as it applies to an understanding of fuel reprocessing.
- Analytical Chemistry: The investigation of novel methods of analysis of general applicability to the nuclear program and analyses to meet the requirements of the underlying research program.

77-78 Funds: (See 3.3.5 Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.



Task: Nuclear Energy  
Program: Nuclear Utilization & Support  
Subprogram: Underlying and Advanced System Research (Sheet 3 - Materials Science)

#### OBJECTIVE

To provide the mission support and awareness functions, the focus will continue to be on maintaining positions at the forefront of international research in the areas of:

- basic interactions of point defects, dislocations, radiation damage etc. leading to an understanding of deformation processes in zirconium alloys.
- surface phenomena.
- the penetration of charged particles.

#### WORK

Work can be categorized as:

- Defects - Radiation Damage: Studies of the behaviour of crystal lattice defects by electron microscopy, internal friction, ion channeling and backscattering, positron annihilation, electron resistivity and related techniques. Investigation of radiation damage and the kinetics of void and bubble growth by both in-reactor work and simulation tests using electron and ion beams.
- Surface Phenomena: Studies of electronic, ionic and molecular transport in zirconium oxide and related films; topography of Zr-ZrO<sub>2</sub> interfaces; computer processing of electron microscope and electron diffraction images; chemical reactions at metal surfaces in H<sub>2</sub>O - H<sub>2</sub>S environments.
- Charged Particle Penetration: In obtaining a fundamental understanding of the interactions of energetic ions and atoms with solids, this work involves studies of phenomena such as energy loss, ion scattering and excitation, and radiation damage. Particular emphasis has been given to studies of crystalline materials and, more recently, to the crystal surface. These studies have involved the development of techniques such as heavy-ion channeling, Rutherford backscattering, nuclear microanalysis and ion-induced X-rays.

For funding see 3.3.5 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

1978-80

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: Underlying and Advanced Systems Research (Sheet 4 - Advanced Systems Research)

#### OBJECTIVE

The goals of the advanced-systems program are to keep open, for the long term, the electronuclear breeding option, to assess long-term nuclear alternatives to fission, particularly fusion, and to reap short-term benefits from the associated technology. Two approaches to electronuclear breeding seem feasible with developments, the accelerator breeder and the fusion breeder.

Like the fast-breeder reactor and the self-sufficient thorium fuel cycle, the electronuclear breeder offers the possibility of a many-fold increase in the amount of energy obtainable from the world's uranium and thorium resources. In the accelerator-breeder concept, protons from an ion source are accelerated in a linear accelerator and impact on a heavy-element target (e.g., bismuth) to produce neutrons. These neutrons are slowed down and absorbed in either a uranium or thorium blanket to produce, respectively, plutonium or uranium-233 and heat. The heat generated is recovered to produce electricity and the plutonium or uranium 233 can be separated to produce fuel for nuclear power reactors. To be practical, the system must produce beam powers of at least 300 MW (e.g., proton currents of 300 mA and energies of 1000 MeV). In the fusion breeder a fusion device would provide neutrons to the blanket of fertile material. At the present time the accelerator breeder is considered the easier technology to develop.

Thus, work must be done on ion sources, accelerators, spallation targets, thorium or uranium blankets and heat-removal systems before a practical system is developed.

#### WORK

Work to date has concentrated on the development of ion sources and accelerators to assess the practicality of reaching the required current/energy levels. Current and energy levels are now at 16 mA and 4 MeV, respectively, in an electron test accelerator designed to simulate and solve problems of launching high-current continuous proton beams in an accelerator breeder and accelerating these beams with minimum loss to the required energies. Development of the low-energy stages of a proton accelerator is making good progress; the ion source, for example, has achieved a current of 425 mA. Some of the technology is common to certain areas of fusion technology and efforts are underway to strengthen such overlap. In the interim, spinoff technology has produced a new accelerator (the turn-around LINAC for cancer therapy) which is now at the prototype stage in the Radiochemical Company.

For funding see 3.3.5 (Sheet 1)

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

Task: Nuclear Energy  
Program: Nuclear Energy Utilization and Support  
Subprogram: New Applications

## OBJECTIVE

To assess, on a continuing basis, the economics and status of other energy options (nuclear and non-nuclear) so that AECL remains up-to-date on the competitive position of its current technology and is alert to new applications for it. The most important current objective is to identify areas where nuclear energy can substitute for oil and develop the appropriate technology.

## WORK

Among the areas identified for examination are:

- the use of CANDU-reactors in the recovery of oil from the tar sands
- the use of an up-rated SLOWPOKE reactor for centralized district heating
- reactor heat for industrial process-heat applications
- reactor-supplied base-load electricity for space heating with fossil fuels being used for peaking purposes
- reactor waste heat, for agriculture and aquaculture
- nuclear energy for the production of alternative fuels, such as hydrogen
- nuclear-based electricity for transportation.

Funding was included in 3.3.1 in 78-79 and 79-80.

Subprogram Mr. J.A.L. Robertson, Atomic Energy of Canada Ltd., Chalk River,  
Director: Ontario, K0J 1J0. 613-687-5581.

Task: Nuclear Energy  
Program: Fusion  
Subprogram: Inertial Confinement

#### OBJECTIVE

To perform "internationally respected" science which contributes to the world pool of knowledge in this field and hence permit Canada to develop a scientific understanding of similar activities elsewhere.

#### WORK

During 1976-79 NRC's laboratory efforts resulted in considerable progress in several areas of knowledge applicable to inertial confinement, for example:

- the study of CO<sub>2</sub> laser-plasma interactions and the effectiveness of CO<sub>2</sub> lasers for inertial confinement
- the application of laser scattering to the investigations of nonlinear process in CO<sub>2</sub> laser/high density plasma interactions.
- the development of continuously tunable infrared lasers of amplifiers for short high peak power pulses (in cooperation with industry).

During 1979-80 NRC continued its efforts in laser-plasma interactions, diagnostics, theoretical studies, gas laser and optical component development. These efforts involve industrial companies through contracts under NRC's PILP program. Some notable successes in gas laser development resulted in a reorientation during 1979-80 of part of this work in order to exploit a special opportunity for its application in the related field of laser chemistry.

During the next four years the effort is to be concentrated on the development and use of CO<sub>2</sub> lasers with pulse energies of the order of 1 kilojoule. The aim is to determine whether CO<sub>2</sub> lasers are suitable for the compression and heating of plasmas towards fusion conditions.

78-79 Funds: \$2,230,000

79-80 Funds: \$2,254,000

Subprogram Dr. T.S. Brown, Division of Physics, National Research Council, Montreal  
Director: Road, Ottawa, Ontario K1A 0R6. 613-993-0810

Task: Nuclear Energy  
Program: Fusion  
Subprogram: Materials for Fusion Reactors

#### OBJECTIVE

To contribute to the world pool of knowledge on the materials and engineering of fusion reactors and hence permit Canada to maintain an awareness and develop a scientific understanding of similar activities elsewhere.

#### WORK

Work in this subprogram was initiated during 1978-79 and is still very limited. Some scientists and engineers have been posted for training to the TEXTOR project in West Germany under an IEA agreement and some small, existing university groups in Canada are receiving limited support. Most of the effort is being concentrated on defining a narrowly focussed topic in which, by exploiting indigenous skills or capabilities, Canada could contribute significantly and thereby gain access to the large international effort.

78-79 Funds: \$47,000

79-80 Funds: \$125,000

Subprogram Director: Dr. T.S. Brown, Division of Physics, National Research Council, Montreal  
Road, Ottawa, Ontario K1A 0R6. 613-993-0810



Task: Nuclear Energy  
Program: Fusion  
Subprogram: Magnetic Confinement

#### OBJECTIVE

To put Canada in a knowledgeable position on the magnetic confinement approach to controlled fusion as rapidly and efficiently as possible and to maintain the minimum essential core of expertise from which to expand if magnetic confinement is demonstrated to be the most promising method of achieving controlled nuclear fusion.

#### WORK

In 1979-80 this work consisted of monitoring international developments - in particular the proposed, large (\$1 Billion) INTOR project being planned by the U.S.S.R., U.S.A., Japan and Euratom - and posting an engineer to the Princeton Plasma Physics Laboratory for training. But the greatest effort was devoted to preparing a detailed conceptual design and research program for a special, high-duty-factor, research Tokamak to be located at Varennes, Quebec. This detailed planning is a joint effort between NRC and a group of Quebec organizations led by Hydro Quebec. Although this Tokamak facility would be small in comparison with existing facilities in other countries, its special characteristics would be of international interest and the expertise gained in its operation would assure Canadian awareness and understanding of international developments in the main line of magnetic confinement R/D.

78-79 Funds: \$305,000

79-80 Funds: \$305,000

Subprogram Dr. T.S. Brown, Division of Physics, National Research Council, Montreal  
Director: Road, Ottawa, Ontario, K1A 0R6. 613-993-0810

TASK 4  
RENEWABLE ENERGY

## Introduction To TASK 4: RENEWABLE ENERGY

Some of the information that follows has been extracted from the National Research Council publication "RENEWABLE ENERGY - Research and Development in Canada, M.S. Chappell, Energy Project Office, NRC, December 1979. NRC No. 17978 (Français 17979)".

Canada now obtains over 10% of her energy supplies from renewable energies - predominantly hydro electric power and forest wood wastes. Further utilization is hindered by the high capital cost of conversion equipment and the consequently high cost of renewable energy when transformed to convenient forms. However, as supplies of traditional energies dwindle and their prices rise, and as renewable energy technologies gain maturity, the disparity is lessening and the renewables are becoming economically attractive.

The potential of renewable energy in Canada is immense and could ultimately meet most of the country's energy needs. However, the near term economically and technically practical potentials are much more modest. Nevertheless, the contribution of renewable energy is realistically forecast to double by the year 2000 - only 20 years from now. The emphasis of this Task is directed towards establishing cost effective processes, techniques, and equipment to make this contribution possible.

The Task Coordinator is:

Dr. R.P. Overend  
Energy R&D Programs Branch, Bldg. M-50  
National Research Council  
Ottawa, Ontario, K1A 0R6  
613-993-3405

This Task is divided into five Programs.

### 4.1 Hydraulic Energy

Canadian expertise in conventional hydroelectric power generation resides in provincial utilities and in the private sector; much of the federal support is through the Canadian Electrical Association (see Sub program 5.2.1). The Program is focussed on the more novel forms of hydraulic power, including wave (4.1.1), river and tidal current (4.1.2) and hydrothermal energy (4.1.3). The technology of civil works and hydraulic machinery applicable to tidal power exists but there remains a need for modelling of planned projects. Thus physical and computer modelling (4.1.4) is being developed with emphasis on, but not limited to, the Bay of Fundy tidal schemes.

The Program Convenor is:

Mr. J. Ploeg  
Section Head  
Hydraulics Laboratory, Bldg. M-32  
National Research Council  
Ottawa, Ontario, K1A 0R6  
613-993-2417

## 4.2 Solar

The objective of the Solar Program is to establish when and where solar energy can be used to advantage in Canada, particularly to replace fossil fuels, by initiating, sponsoring, encouraging, and promoting the development of Canadian solar technology, and of a Canadian industrial capability based upon that technology.

The solar resource, little studied until recent years, is being quantified (4.2.2) with measurements of both integrated solar radiation and spectral energy distribution. In parallel, Subprograms have supported the technology of collecting this resource as heat such as passive solar space heating. They are fundamental studies on solar heating systems (4.2.1) and industrial technology and product development (4.2.4). Beyond solar heating are the photovoltaic and photochemistry technologies; these, too, are being studied (4.2.3).

Complementing the support of technical development in the relatively new area of solar energy is the response to the need for accepted test methods and standards, especially for Canadian conditions (4.2.9).

The preceding provides a base from which to conduct (4.2.5) and monitor (4.2.8) solar system heating trials which have grown to be a significant part of this Program. The emphasis has been on domestic space and water heating and on hot water heating at commercial sites. Because of the complexity of solar heating/cooling of commercial buildings, a Subprogram (4.2.7) is developing a capability for analyzing them.

The potential of agriculture as a user of solar energy is recognized (4.2.6) with studies on, for example, grain drying and greenhouses.

All the preceding work, producing a fast-growing and disparate fund of information, is made available to the public through various information systems (4.2.10).

The Program Convenor is:

Mr. R.M. Aldwinkle  
Solar Energy Project, Bldg. M-24  
National Research Council  
Ottawa, Ontario, K1A 0R6  
613-993-2730

## 4.3 Biomass

This Program is directed towards utilizing the potential energy value in waste residues from agricultural and forestry crops. Resource assessment (4.3.1) and studies of environmental effects (4.3.2) are essential to this energy source which until recently was tapped with much less emphasis than the traditional sources of oil, gas and coal. Cooperative work is undertaken at both the international (4.3.3) and provincial (4.3.4) levels. Production technologies covered are harvesting and collecting (4.3.5) and conversion, including fermentation, pyrolysis, gasification and direct combustion (4.3.6). The technology transfer mechanism includes technical information dissemination (4.3.8). Long range, fundamental studies (4.3.7) provide the basis for future advances.

The Program Convenor is:

Dr. R.P. Overend  
Energy R&D Programs Branch, Bldg. M-50  
National Research Council  
Ottawa, Ontario, K1A 0R6  
613-993-3405

#### 4.4 Wind Energy

The main focus of the Wind Energy R&D Program is towards the development in Canada of vertical axis wind turbine generators (VAWTG's) which can contribute significant amounts of energy to the nation's electrical networks. The Program includes experimental and analytical methods to quantify the variable and geographically non-uniform resource (4.4.1) and development of small-scale VAWTG's for remote communities and special applications (4.4.2). These latter machines also serve as field trial models for the development of megawatt-scale grid-coupled VAWTG's (4.4.3) that will supply electricity directly into existing power networks.

The Program Convenor is:

Mr. M.S. Chappell  
Energy R&D Programs Branch, Bldg. M-50  
National Research Council  
Ottawa, Ontario, K1A 0R6  
613-993-3405

#### 4.5 Geothermal Energy

Geothermal energy is being tapped in many places throughout the world and promises to play a small but important role in Canada's energy future. To date, the Canadian federal program has concentrated on the identification and assessment of geothermal sources. Work is proceeding in the most favourable areas in the country - the western mountains and the western sedimentary basins. In the western mountains, work has been divided into the delineation of regional geothermal anomalies (4.5.1) and the identification and assessment of specific localities (4.5.2).

In the sedimentary basins (4.5.3) the resources are more uniformly distributed and are being studied with a prototype system to provide energy for space heating at the University of Regina.

The Program Convenor is:

Dr. A.M. Jessop  
Earth Physics Branch  
Division of Seismology and Geothermal Studies  
Department of Energy Mines and Resources  
1 Observatory Crescent  
Ottawa, Ontario, K1A 0Y3  
613-995-5490



Task: Renewable Energy Resources  
Program: Hydraulic Energy  
Subprogram: Wave Energy

## OBJECTIVE

To support selected technologies that may offer advantages for the use of Canada's wave energy potential.

## WORK

Preliminary examinations of wave energy in Canada's coastal waters suggest a modest potential. Scale model tests of a few conversion devices have shown that up to 80% of the theoretically available wave energy could be extracted over a reasonably wide range of wave periods. However, the results were not any better than those from a multitude of devices tested in the United Kingdom. NRC is also participating, on behalf of Canada, in international projects on wave energy under the auspices of the IEA. A collaborative effort has resulted in agreed analytical techniques for assessing wave energy potential. Currently, NRC is participating in an IEA project off the coast of Japan to test a large vessel-type buoy, the KAIMEI, which converts potential wave energy into mechanical and electrical energy via air chambers, air turbines, and generators. NRC is supplying wave measuring devices, and is responsible for the analysis of the wave data, in addition to a cash contribution to this joint program. Results from these assessments of wave energy potential, and the performance and likely cost of conversion devices, have suggested that only in unique locations, perhaps in combination with requirements for breakwaters, can this resource be considered as a valid alternative in Canada. Further research on wave energy will be guided in this direction.

Funds below are for all of Subprograms 4.1.1 to 4.1.4.

78-79 Funds: \$621,000

79-80 Funds: \$375,000

Subprogram Mr. J. Ploeg, Hydraulics Laboratory, Bldg. M-32, National Research  
Director: Council, Ottawa, Ontario, K1A 0G6 613-993-2417

Task: Renewable Energy Resources  
Program: Hydraulic Energy  
Subprogram: River and Tidal Current Energy

#### OBJECTIVE

To support selected new technologies that may offer advantages for the use of Canada's river and tidal energy potential.

#### WORK

Subprogram considers the concept of installing a turbine in an existing current, either tidal or river flow, without the expensive civil works such as reservoirs, dams and spillways. The hydraulic equivalent of a windmill is perhaps an apt analogy. The concept and a preliminary assessment of potential are encouraging, especially in Canada's many remote communities where the hydraulic resource would be an attractive adjunct to current fossil fueled generator plants. A facility for testing such devices has been commissioned in the Hydraulics Laboratory and a promising Canadian concept, involving a vertical axis turbine, is currently under test.

See also Subprogram 4.1.4 for modelling techniques applied to tidal energy, especially with respect to the Bay of Fundy.

For funding see 4.1.1

Subprogram Mr. J. Ploeg, Hydraulics Laboratory, Bldg. M-32, National Research  
Director: Council, Ottawa, Ontario K1A 0R6 613-993-2417

1978-80

Task: Renewable Energy Resources  
Program: Hydraulic Energy  
Subprogram: Hydrothermal Energy

#### OBJECTIVE

To support selected technologies that may offer advantages for the use of Canada's hydrothermal energy potential.

#### WORK

This Subprogram includes examination of energy extraction potential from relatively small temperature differences between large bodies of fluid. The primary study to date has been for the Strait of Belle Isle. This unique location combines a potential source of hydrothermal energy and a tidal phase difference between the Labrador Sea and the Gulf of St. Lawrence. Results of this study are currently being evaluated. Other hydrothermal potentials are found in the stratification in hydro electric reservoirs, and ocean water to air temperature differences in the far north.

For funding see 4.1.1

Subprogram Mr. J. Ploeg, Hydraulics Laboratory, Bldg. M-32, National Research  
Director: Council, Ottawa, Ontario, K1A 0R6 613-993-2417

1978-80

Task: Renewable Energy Resources  
Program: Hydraulic Energy  
Subprogram: Modelling Techniques

#### OBJECTIVE

To support new hydraulic energy extraction concepts by developing physical and mathematical modelling techniques.

#### WORK

Beyond the increased use of conventional hydro electrical technology, extraction of energy from the phenomenally high tides in the Bay of Fundy is the largest single project now planned for increased use of hydraulic energy in Canada. The recent report of the Bay of Fundy Tidal Review Board recommended an in-depth study of the Cumberland Basin as the next step to develop this site, with an annual power potential of 3,423 GWh, or the equivalent of 3 million barrels of oil per year. In view of recent international developments, particularly concerning oil supplies to the Maritimes, the development of tidal power is likely to receive high priority in the immediate future. The civil works and the hydraulic machinery required for even this massive project are well established in industry, and thus require little, if any further research. However, it is clear that planning and construction of such a large hydraulic system will require accurate dynamic modelling techniques to predict performance of the various alternative arrangements and to assess physical and environmental side effects over a considerable area surrounding the project itself. To address this need, a new modelling technique is being developed by NRC's Hydraulics Laboratory which dynamically couples a physical or hydraulic model and a mathematical model. The hybrid model makes use of recently developed "array processors" to describe the more linear outer parts of the system and to control the boundary conditions of a large-scale physical model of the highly non-linear inner part of the system. Although initially directed toward the Fundy tidal power project, this modelling technique has the potential of being applicable to other new hydraulic energy extraction concepts.

For funding see 4.1.1

Subprogram Mr. J. Ploeg, Hydraulics Laboratory, Bldg. M-32, National Research  
Director: Council, Ottawa, Ontario, K1A 0R6 613-993-2417

1978-80

Task: Renewable Energy Resources  
Program: Solar Energy  
Subprogram: Fundamental Studies (Studies on solar heating systems and their application to buildings)

#### OBJECTIVE

To develop technical information related to solar systems and components (a) to assist builders, designers, material and component manufacturers/suppliers and building owners in introducing solar heating systems into Canadian building practice; and (b) to indicate directions for future system trials and industrial R&D support.

#### WORK

Areas of study include:

- Feasibility studies on solar heating systems in different building types and locations. Systems studied were active solar space heating service water heating and solar-assisted heat-pumps. Air-to-air heat pumps were found to be more attractive than active solar systems.
- Study on the durability and reliability of solar components and systems, including attention to corrosion problems.
- Development of methods and formats for assessing the worth of solar collectors.
- Study of in-ground heat storage in solar heating systems, including insulation methods.
- Studies to assess performance of solar systems and to predict system behaviour by computer simulation methods.
- Study on the potential for passive solar heating in Canada.

78-79 Funds: \$310,000

79-80 Funds: \$450,000

Subprogram J.R. Sasaki, Division of Building Research, National Research Council,  
Director: Montreal Road, Ottawa, Ontario, K1A 0R6 613-993-1421



1978-80

Task: Renewable Energy

Program: Solar Energy

Subprogram: Resource Assessment (Sheet 1 - Integrated Solar Radiation Measurements)

#### OBJECTIVE

To gather data on direct, diffuse and global solar radiation integrated over the solar spectrum i.e., not expressed as a function of wavelength, for all regions of Canada at hourly intervals. The data base thus obtained is available for the design of solar collectors and systems.

#### WORK

This is a continuing project to build up the data base by measurement and by the estimation of solar radiation at sites where hourly meteorological information is available. The data are presented in forms suitable for various applications. Equipment to improve the efficiency of data collection and processing is added when feasible.

The Atmospheric Environment Service has participated actively with the IEA, under Task IV of the Implementing Agreement on the R&D Program on Solar Heating and Cooling, in the development of an insolation handbook and instrumentation package. AES also is the lead Canadian agency in Task IV of the Implementing Agreement, the use of existing meteorological information for solar energy applications.

The funds below are for all of Subprogram 4.2.2

78-79 Funds: \$779,000

79-80 Funds: \$779,000

Subprogram Dr. D.C. McKay, Fisheries and Environment Canada Atmospheric Environment  
Director: Service, 4905 Dufferin Street, Downsview, Ontario. 416-667-4626.

Task: Renewable Energy  
Program: Solar Energy  
Subprogram: Resource Assessment (Sheet 2 - Solar Spectral Energy Distribution)

#### OBJECTIVE

Measurement and establishment of data base for spectral distribution of solar radiation at ground level for all regions of Canada for any orientation of the energy collector at any time of the year.

#### Sub-objective

Development of a portable instrument which will synthesize spectra, from a few spot readings at chosen wavelengths, using an eigenvector method.

#### WORK

In 1978-79, apparatus for measurements of spectra and accompanying pertinent data, such as cloud cover, were set up at two sites, one at NRC in Ottawa and one at York University in Toronto.

The results of measurements at these two sites will be used to design a portable instrument capable of synthesizing spectra for any site from spot readings taken at a few special wavelengths. The collection of data at the two sites is now underway and should continue until the end of fiscal year 1981-82 to ensure a reliable data base for the design of the instrument.

For funding see 4.2.2 (Sheet 1)

Subprogram Dr. G.W. Wysecki, Division of Physics, National Research Council,  
Director: Ottawa, Ontario. K1A 0R6 613-993-2504

1978-80

Task: Renewable Energy  
Program: Solar Energy  
Subprogram: Advanced Scientific Projects (Sheet 1 - Photovoltaics)

## OBJECTIVE

To develop low-cost photovoltaic devices (solar cells) suitable for operating under Canadian climatic conditions; to promote the manufacture of such devices.

### Sub-objectives:

To establish cooperation between companies with manufacturing potential in this field and university groups in which most of the advanced research and development is taking place.

In the shorter term (5 years or less), to provide energy sources for remote locations in Canada and elsewhere where energy needs per site are small but vital.

In the long term (20 to 30 years), to develop a source of electricity which can supplement that from other sources.

## WORK

The following areas have been studied:

- Low-cost thin film ( $\text{CdS} - \text{Cu}_2\text{S}$ ) solar cells.
- Inversion layer silicon solar cells.
- Polycrystalline silicon solar cells.
- n-n heterojunction solar cells.
- Surface junction silicon solar cells.
- Zone crystallization of amorphous silicon.
- Semiconductor-insulator-semiconductor solar cells using recrystallized powder technology.

In addition a market survey is being made of possible applications of solar cells in Canada.

78-79 Funds: \$550,000

79-80 Funds: \$700,000

Subprogram Dr. J.H. Simpson, Solar Energy Project, National Research Council,  
Director: Ottawa, Ontario, K1A 0R6 613-993-9924

Task: Renewable Energy  
Program: Solar  
Subprogram: Advanced Scientific Projects (Sheet 2 - Photochemical Devices and Systems)

#### OBJECTIVE

To develop devices or systems that use sunlight to produce photochemical reactions leading to one of the following:

- production of electricity, with or without storage i.e., photogalvanic
- production of hydrogen from water

#### WORK

The following areas have been studied:

- organic solar cell studies and the photochemical generation of hydrogen
- production of hydrogen from water at high temperatures using solar energy
- photocatalytic system to produce hydrogen from water

78-79 Funds: \$130,000

79-80 Funds: \$150,000

Subprogram Director: Dr. J.H. Simpson, Solar Energy Project, National Research Council,  
Ottawa, Ontario, K1A 0R6 613-993-9924

1978-80

Task: Renewable Energy Resources  
Program: Solar  
Subprogram: Industrial Technology and Product Development (Sheet 1 - Collector Development)

#### OBJECTIVE

By providing R&D support, to foster the creation in Canada of industrial competence in the design, manufacture and application of solar collectors.

#### WORK

This work is directed at (1) generating technology of value to the emerging industry generally (2) the development of commercial products that will be reliable, durable, and cost-effective.

It encompasses at present solar collectors of widely different type, performance and cost.

In 1978-79 work under contract investigated the technologies of various kinds of flat plate collectors. Studies were also made of corrosion, selective absorber materials and collector ranking methods.

Recent studies have been on:

- collectors of the concentrating, evacuated, heat pipe, thermosyphon, matrix, honeycomb and glazed plastic types
- glazing materials and selective glazing
- the deposition of selective surfaces
- solaria and heat conserving windows
- packaged domestic hot water systems

Under Task III of the IEA Implementing Agreement on Solar Heating and Cooling, Canada is participating with 13 member countries in "round robin" testing of solar collectors. The prescribed series of tests on the Chamberlain (U.S.) collector have been completed.

The funds below are for all of Subprogram 4.2.4

78-79 Funds: \$1,070,000

79-80 Funds: \$1,970,000

Subprogram K.G. Lund, Solar Energy Project, National Research Council, Montreal  
Director: Road, Ottawa, Ontario, K1A 0R6 613-993-2730



1978-80

Task: Renewable Energy Resources  
Program: Solar  
Subprogram: Industrial Technology and Product Development (Sheet 2 - Heat Exchange and Storage; Auxiliary Equipment and Controls)

#### OBJECTIVE

By providing R&D support, to foster the creation in Canada of industrial competence the design, manufacture and application of solar systems and equipment (other than collectors).

#### WORK

In 1978 a hybrid computer simulation study was made of control strategies for solar heating. Work on storage encompassed the air/rock system, two chemical methods, two latent heat methods and one solution method.

Studies being carried out in 1979 include: (1) the interaction of solar system architecture and control strategy; (2) rapid hybrid computer modelling of new systems; (3) storage of hot water in unlined concrete tanks; and (4) a simplified system sizing procedure.

Contracts are being let for the design of ice and wax storage systems and an air handling systems.

For funding see 4.2.4 (Sheet 1)

Subprogram K.G. Lund, Solar Energy Project, National Research Council, Montreal  
Director: Road, Ottawa, Ontario, K1A 0R6 613-993-2730

1978-80

Task: Renewable Energy Resources  
Program: Solar  
Subprogram: Solar Heating System Trials

## OBJECTIVE

The objectives are:

- To obtain data on the performance and cost-effectiveness of solar systems in providing space and hot water heating in Canadian buildings;
- To indicate the problems that are encountered in the design, installation, operation, and servicing of solar systems in Canada under Canadian climatic and living conditions;
- To provide visible demonstration to the public of the applications of solar energy.

## WORK

In 1976-77, support was provided for introduction of solar heating systems in 14 single-family detached houses across Canada, including seven liquid systems and six air/rock systems. In 1977-78, contracts for solar heating systems trials in 12 small multi-unit residential buildings were initiated.

In the 1978-79 Systems Trials Program, for solar commercial hot water heating, 53 proposals were received and ten firms or consortia have been awarded contracts amounting to a total of approximately \$1.5 million over a period of 18 months.

Results to date have shown that, in general, the state of the technology and of the industry have been overestimated and the length of time to plan a project and to obtain and report useful results has been under estimated. More detailed observations are that the installation of active solar systems in existing buildings is a more difficult and expensive task than commonly expected, and emphasis must be placed on reducing the cost.

In 1979-80, work on these units is being extended and the earlier data evaluated to indicate improvement possibilities and necessary repairs. A survey is also being made of passive solar systems in Canada with the object of selecting suitable candidates for detailed analysis.

With respect to the IEA Implementing Agreement on the R&D Program on Solar Heating and Cooling, Canada and Sweden have proposed a new task on district-heating using a solar seasonal heat storage system. Sweden has a sizable program in place. The proposals were made at the meeting of the Executive Committee in Stockholm, 23 October 1978, and a new Task is under negotiation. One of the heat collection sub-systems which will be investigated is a heliostat field reflecting solar radiation to a central receiver rather than field of flat plate collectors transferring the heat to the central storage. Such a system would reduce the thermal mass of the heat transmission fluid and appear to reduce thermal losses.

78-79 Funds: \$766,000

79-80 Funds: \$1,960,000

Subprogram G. Yen, Solar Energy Project, National Research Council, Montreal Road,  
Director: Ottawa, Ontario, K1A 0R5 613-993-9224

Task: Renewable Energy Resources  
Program: Solar Energy  
Subprogram: Agricultural Applications

## OBJECTIVE

To develop and evaluate solar applications in agriculture such as heating of ventilation air, solar grain drying, solar collection systems, and components for agriculture use and multi-use solar collector systems. Also under study are the conception, design and evaluation of solar adapted greenhouses.

This Subprogram is also intended to achieve a 95% reduction in the fuel costs of greenhouses by 1983.

## WORK

In 1977-78 a preliminary program for development and demonstration of solar applications in agriculture was started. As a result, four contracts were implemented as follows:

- solar heating of a hog barn
- solar heating of an anaerobic digester
- feasibility study on solar heating of dairy wash water
- assessment of simple solar collectors for grain drying

Based on the need for further research in this area and the results of the projects implemented, the program was enlarged for 1978-79 to include:

- solar heated hog barn (continuation)
- solar collector/storage wall
- solar collectors for grain drying
- solar collectors for agricultural use
- multi-use solar collectors
- low energy greenhouse
- solar heated greenhouse

In 1979-80 emphasis was on solar energy utilization in calf housing, farrowing barns, and poultry broiler buildings all of which require relatively high inside temperatures and are currently high users of energy for space heating. It is hoped to reduce heating costs by at least 30% by 1983. As well, it is intended to promote, by means of demonstration and monitoring, the more promising solar grain driers and agricultural solar collectors currently being studied.

78-79 Funds: \$370,000

79-80 Funds: \$350,000

Subprogram Dr. J. Munroe, Engineering and Statistical Research Institute,  
Director: Agriculture Canada, Ottawa, Ontario 613-995-3151

1978-80

Task: Renewable Energy Resources  
Program: Solar Energy  
Subprogram: Solar Heating/Cooling of Commercial Buildings

#### OBJECTIVE

To develop an analytical capability related to applications of solar energy systems to commercial buildings; and to determine if solar heating of commercial buildings in Canada can be cost-effective.

#### WORK

In 1978-79 a contracted computer simulation of a retrofit installation of solar space heating/cooling in a typical office building was completed. This study showed it was not cost-effective at current energy prices. A design program for solar-assisted service water systems was started. Development was also begun on aids for intercomparing energy systems options (including solar) at the conceptual level of design (Energy Systems Concept).

In 1979-80 the following activities were conducted to provide assistance to the PUSH program.

- Service water design feasibility study. Results available to design consultants through PWC/Computer Aided Design (CAD) and commercial bureaus.
- Development of the Energy Systems Concept program.
- Application of the TRNSYS solar simulator through the PWC/CAD network, and development of user oriented input/output routines.

78-79 Funds: \$101,000

79-80 Funds: \$193,000

Subprogram R.C. Biggs, Solar Energy Project, National Research Council, Montreal  
Director: Road, Ottawa, Ontario, K1A 0R5 613-993-2730

1978-80

Task: Renewable Energy Resources  
Program: Solar Energy  
Subprogram: Monitoring

## OBJECTIVE

The objectives are:

- to accumulate data on the performance of solar heating systems in a variety of building types under Canadian climatic conditions;
- to analyse these data; and
- to use these data to verify analytical tools and give direction for future design criteria, industrial product development and systems trials.

## WORK

Monitoring of NRC Phase I System Trials. Instrumentation of 12 solar heated homes began in 1976 and continued into 1979.

Instrumentation and Monitoring of Non-NRC Projects. Contracts for installation of monitoring instrumentation were let in 1977-78 for one multi-unit Senior Citizen Home, two schools and two office buildings. The intent of these projects is to obtain data at an early date on system types that are not included in current NRC system trials. Monitoring of the projects continues.

Instrumentation and Monitoring of NRC Phase II System Trials. (Multi-unit residential buildings). A contract for the instrumentation and monitoring of Phase II projects is being let.

Instrumentation and Monitoring of NRC Phase III System Trials. (Non-residential service water heating). A contract for the instrumentation and monitoring of these projects is being let.

Instrumentation and Monitoring of Passive Solar Houses. A contract to develop methods of monitoring passive solar heating systems is being let. A number of different types of passive houses will be instrumented.

Instrumentation and Monitoring of Selected Projects Undertaken under either the PUSH or Federal/Provincial Demonstration Programs. Contracts will be let in 1979/80 and subsequently to obtain data on system types not included in current system trials or where current trials show more data is required.

78-79 Funds: \$460,000

79-80 Funds: \$1,180,000

Subprogram J.R. Sasaki, Division of Building Research, National Research Council,  
Director: Montreal Road, Ottawa, Ontario K1A 0R6 613-993-1421



1978-80

Task: Renewable Energy Resources  
Program: Solar Energy  
Subprogram: Test Methods and Standards

## OBJECTIVE

Objectives of this Subprogram are:

- to develop test methods and standards appropriate for Canadian conditions;
- to permit the objective comparison of the thermal performance, the reliability and the durability of components used in solar systems; and
- to ensure that adequate test facilities are available as required.

## WORK

Collector calorimetry. Determining the suitability of ASHRAE methods (93-77) for evaluating collector types under Canadian operating conditions; determining the validity of standard collector test for the thermal performance of collector arrays under variable-sky conditions; and establishing norms for Canadian collector performance. NRC is also participating in the International Energy Agency Solar Heating and Cooling Program, Task III (Test Methods).

Collector exposure study. Inferring durability and reliability of solar collectors by subjecting them to simulated operating conditions and stagnation conditions; determining changes in physical and optical properties as well as in the thermal performance.

Material durability studies. Material durability studies is the alternative path for inferring durability and reliability of solar collectors. NRC activity involves optical studies of collector cover materials and absorber coatings. Contracts have been let to study the durability of plastic glazing material and the behavior of concrete hot water storage tanks. The NRC is also involved in ASTM work (E44) which is responsible for both component and material durability test methods.

Round Robin Collector Testing. Providing round robin test samples to commercial testing laboratories.

Development of Solar Component Standards. A contract has been let to the Canadian Standards Association to develop an interim solar collector performance standard. Development of standards for pre-packaged residential solar service water heating systems will also be considered. For items such as heat storage units which are difficult to standardize, recommended practice guidelines will be developed.

Establishment of Solar Collector Test Facilities. A prototype indoor test facility is being installed at the Ontario Research Foundation Site in Toronto and a review of the requirement for additional regional test facilities is being conducted.

78-79 Funds: \$90,000

79-80 Funds: \$130,000

Subprogram J.R. Sasaki, Division of Building Research, National Research Council,  
Director: Ottawa, Ontario. K1A 0R6 613-993-1421

1978-80

Task: Renewable Energy  
Program: Solar Energy  
Subprogram: Information and Liasion

## OBJECTIVE

The objectives are:

- to establish a working system for collecting, organizing and distributing technical information in the field of solar energy;
- to establish a Solar Technical Information System as part of the CISTI National Energy Library;
- to issue reports to meet the needs of policy makers, designers, engineers, manufacturers, the service industry, and consumers;
- to maintain contacts for the useful exchange of information with other programs both national and international.

## WORK

- (a) Considerable progress has been made in data collection and evaluation on existing solar projects, federal and private. Four major publications have been completed, one in the NRC Solar Technical Series and three in the NRC Solar Information Series. Dissemination networks have been established and 20,000 copies of the first number of the Solar Information Series have been distributed.
- (b) Negotiations with the Canadian Institute for Scientific and Technical Information have led to the establishment of a Renewable Energy Information Centre based on CISTI. Progress has been made with a Computer Activated Information System for Solar Energy (CAISSE) as a first step in developing a machine-accessible information system for solar energy technical information.
- (c) Contacts have been established with the Solar Energy Research Institute (U.S.A.) with preliminary agreement on information exchange. This office has participated in three meetings of the IEA Solar Heating and Cooling Task Force. One result is that Canada (AES) will edit and publish the IEA Handbook on meteorological measurements and data handling for solar energy.

78-79 Funds: \$320,000

79-80 Funds: \$510,000

Subprogram Solar Energy Project, National Research Council, Montreal Road, Ottawa  
Director: Ontario, K1A 0R6 613-993-9224

1978-80

Task: Renewable Energy  
Program: Biomass Energy  
Subprogram: Resource Assessment

## OBJECTIVE

To determine the availability, renewability and type of energy from Canada's biomass resources.

## WORK

No projects were undertaken in 1977-78.

The fiscal year 1978-79 was regarded as the first of a six year activity. The activity in total is concerned with the supply of forest biomass raw material for conversion to energy, fuel and chemicals. It is being conducted in terms of three elements: scenario (program planning and strategy development); inventory (development and application of methodology to interpret conventional "merchantable timber" inventories in terms of total biomass) and; agroforestry (e.g., growth and yield, site quality, energy biomass plantations).

Most of the work is being contracted out, with additional resources and participation from provincial agencies and the forest industry wherever possible. It is managed by the Canadian Forestry Service's six regional Forest Research Centres and two of the National Forestry Institutes (Forest Management Institute and Petawawa Forest Experiment Station). In the first year major emphasis is being placed upon inventory studies, to produce reliable data on total biomass availability. In-house activities at the eight Canadian Forestry Service establishments involved deal mainly with project planning, evaluation and negotiations within the "scenario" element, as well as contract management of the R&D program.

In 1978-80, 21 contracts were let, 13 in 1978-79 and 8 in 1979-80.

To date no comparable effort on energy crops in agriculture has been considered.

Marine biomass resource estimation and the conversion of high moisture content biomass materials are both included in 1980-81 plans as these could offer significant potential, particularly in eastern Canada.

78-79 Funds: \$229,000

79-80 Funds: \$583,000

Subprogram Director: Dr. T.S. McKnight, Director, Forest Utilisation Branch, Canadian Forestry Service, Fisheries and Environment Canada, Place Vincent Massey, Hull, Quebec. K1A 0E7 613-997-1684

Task: Renewable Energy  
Program: Biomass Energy  
Subprogram: Environmental Effects

## OBJECTIVE

To identify and assess the impact of extended biomass production and harvesting upon ecological systems and to determine methods of ameliorating possible ecological impacts of extended biomass harvesting.

## WORK

The Canadian Forestry Service is supporting:

- a) a study of the impact of short rotations and whole-tree harvests on forest nutrient budgets, nutrient recycling and nutrient losses through harvesting;
- b) an exhaustive literature survey and synthesis of information on the use of biological nitrogen fixation in intensive forest management and;
- c) work to gauge the impact of the operation of a gasifier/generator in a remote community on local employment, lifestyle and the environment.

Six contracts have been let, two in 1978-79 and four in 1979-80.

78-79 Funds: \$216,000

79-80 Funds: \$378,000

Subprogram Dr. T.S. McKnight, Director, Forest Utilization Branch, Canadian Forestry  
Director: Service, 19th Floor, Vincent Massey Building, Hull, Quebec, K1A 0E7  
613-997-1684

GOVERNMENT OF CANADA

1978-80

Task: Renewable Energy  
Program: Biomass Energy  
Subprogram: International Relationships

## OBJECTIVE

Bilateral and multilateral cooperation on biomass R&D is probable with a number of countries that are conducting strong research programs in this area.

## WORK

International collaboration on forestry for energy under the auspices of the IEA has proved to be extremely useful in terms of information exchange. At the third meeting of this activity in Ottawa in March '79 collaborative projects were defined and there appears to be considerable scope for bilateral and multilateral cooperation in the development of harvesting machinery for forest residue and short rotation plantations.

Regular contact is maintained between the program convenor and the IEA, the European Economic Council and programs in the United States.

Canada's current participation with the IEA's activity in "Short rotation forestry for energy" includes participation in the "Biomass Technical Information Service". The program is contributing to specific work on the development of a comprehensive forest biomass growth model to be shared with other IEA members.

78-79 Funds: \$50,000

79-80 Funds: \$45,000

Subprogram Dr. R.P. Overend, Energy Project, National Research Council, Bldg. M-50,  
Director: Montreal Road, Ottawa, Ontario K1A 0R6 613-993-3405



Task: Renewable Energy  
Program: Biomass Energy  
Subprogram: Federal-Provincial Relationships

## OBJECTIVE

To co-operate with other organizations which fund research through co-funding of projects of mutual benefit and through developing systems to achieve transfer of technology.

## WORK

A series of Federal-Provincial agreements in the demonstration of renewable energy and conservation technologies was announced in 1978. It is anticipated that these will provide the vehicle for hardware development and also for development of a biomass inventory in the 1982-83 period following completion of the current R&D efforts. These are supported out of the R&D programs through liaison and advice by scientific authorities as well as co-ordination of the different activities through the co-ordinators and the convenors.

Membership on British Columbia's Wood Waste Committee has resulted in co-funding of resource assessment studies and has guarded against funding of overlapping and non-innovative studies. Similar results have been possible in Alberta and Prince Edward Island via maintenance of a federal biomass connection with the Alberta-Canada Energy Research Fund and the Canada-PEI Renewable Energy Agreement respectively.

Co-funded projects with the Saskatchewan Power Corporation and the Manitoba Research Council deal with wood gasification.

78-79 Funds: \$206,000

79-80 Funds: \$373,000

Subprogram Dr. R.P. Overend, Energy Project, National Research Council, Bldg. M-50,  
Director: Montreal Road, Ottawa, Ontario K1A 0R6 613-993-3405

Task: Renewable Energy  
Program: Biomass Energy  
Subprogram: Harvesting and Collection Technologies

#### OBJECTIVE

To develop equipment and methods dedicated to total biomass recovery, delivery to mill sites and transport of resultant enhanced fuels.

#### WORK

Studies are currently underway:

- to obtain estimates of the cost of collecting, processing and transporting biomass from natural stands to an energy conversion plant,
- to provide an accounting of the physical and economic practicability of utilizing various forms of forest biomass in the productions of energy on Vancouver Island, based upon volume, location, and costs of extraction and transportation and,
- to develop and demonstrate equipment for shipping, logging, chipping, macerating or crushing forest biomass.

Ten contracts have been let in 1978-80, 1 contract in 1978-79 and 9 contracts in 1979-80. These contracts deal with methods and equipment, costs of production and transport and energy input-output in the harvesting and transport operations.

78-79 Funds: \$201,000

79-80 Funds: \$393,000

Subprogram Dr. T.S. McKnight, Director, Forest Utilization Branch Canadian Forestry  
Director: Service, 19th Floor, Vincent Massey Building, Hull, Quebec, K1A 0E7  
613-997-1684

Task: Renewable Energy  
Program: Biomass  
Subprogram: Conversion Technologies (Sheet 1 - Fermentation)

#### OBJECTIVE

To conduct fundamental studies on anaerobic fermentation and to determine the possibility of obtaining liquid and gaseous fuels via anaerobic fermentation of agricultural residues.

#### WORK

Agricultural biomass R&D, under the direction of Agriculture Canada, is presently restricted to examining solution to on-farm energy requirements by the conversion of animal and plant residues to usable energy forms. Developmental-scale anaerobic digesters (one retrofit, the other new) and a straw burner were commissioned on farms this year. All of these have incurred operational difficulties in materials handling and heat transfer and will therefore continue to be monitored and adapted with program funds. Plant residue conversion is likely to be given increasing emphasis over the next two years, while anaerobic digestion R&D will be maintained at its present level so developments of significantly faster anaerobic digester technology can be examined.

Anaerobic digestion is the subject of both applied and fundamental research in NRC's Division of Biological Sciences. The fundamental studies of the anaerobic digester bacteria are viewed as essential to provide an understanding of the "breakdowns" that occur in the high-rate anaerobic digesters developed in the NRC laboratory. The high rate technology (5 volumes of methane per unit volume of digester per day, compared with 0.5-1 vol/vol/day of the currently installed digesters) represents a breakthrough which, if its development is successful, will help to overcome the high capital requirements of current digesters which mitigates against their early adoption.

The funds below are for all of Subprogram 4.3.6

78-79 Funds: \$1,293,000

79-80 Funds: \$3,408,000

Subprogram Dr. R.P. Overend, Energy Project, National Research Council, Bldg. M-50,  
Director: Montreal Road, Ottawa, Ontario K1A 0R6 613-993-3405

Task: Renewable Energy  
Program: Biomass Energy  
Subprogram: Conversion Technologies (Sheet 2 - Pyrolysis)

#### OBJECTIVE

To study the possibility of producing energy by pyrolysis of biomass feedstock.

#### WORK

Work is being undertaken on the pyrolysis of straw and stover materials for the production of energy for the farm sector. A pilot scale study on the utilization of various crop residues using a continuous flow reactor at the University of Sherbrooke is being done to monitor product gases and determine gas liquid and char yield and material balances. The ranges of gas condensates and solid ratios for the input materials according to a variation of operating parameters is also being determined. In 1980 it is anticipated to improve the conversion efficiency by direct heating of the kiln and to assess a coupled pyrolysis/gasification process having the benefits of both while minimizing their disadvantages. An attempt will be made to integrate the waste conversion technology within farming operations, thereby promoting energy self-sufficiency in the agricultural industry.

A second study is being undertaken on the potential use of pyrolysis or gasification systems on farms for the recovery of energy from crop residues. This study includes establishment of the equipment capacity required, review of commercially available equipment, and the development of a system design suitable for use with commercially available equipment. Associated studies relate to: choice of fuel type, development of storage systems, appraisal of economic and energetic efficiencies and estimates of installation costs for selected equipment.

For funding see 4.3.6 (Sheet 1)

Subprogram Dr. R.P. Overend, Bldg. M-50, National Research Council, Montreal Road,  
Director: Ottawa, Ontario, K1A 0R6 613-993-3405

1978-80

Task: Renewable Energy  
Program: Biomass Energy  
Subprogram: Conversion Technologies (Sheet 3 - Gasification)

## OBJECTIVE

To evaluate the feasibility of producing energy by gasification of biomass feedstocks and to develop appropriate technology.

## WORK

Ongoing work supported by EMR includes:

- Development and modification of a prototype reactor at a British Columbia lumber mill to produce low Btu wood gas for local use in the drying kilns.
- Operation of a 20kW batch feed mobile Imbert gasifier on feedstocks of agricultural residues to evaluate the feasibility and economics of farm use for heat and power.

The Canadian Forestry Service has a program for gasification research with support for studies which:

- Evaluate existing wood-residue gasification systems with attention to feedstock performance, fuel pretreatment, the character of the gas produced, and application to a variety of end uses;
- Evaluate fixed-bed wood gasification using chipped round wood as fuel;
- Evaluate an up-scaled British Columbia Research fluidized-bed gasifier coupled to a diesel engine to generate electricity;
- Evaluate a pilot-scale research wood gasifier at the Eastern Forest Products Laboratories;
- Evaluate a wood gasifier at Hudson Bay, Saskatchewan, in cooperation with the Saskatchewan Power Corporation;
- Evaluate the Lamb wet-cell wood burner for firing a pulp mill lime kiln using hogged wood.

The NRC and Transport Canada are investigating the use of methanol in internal combustion engines.

For funding see 4.3.6 (Sheet 1)

Subprogram Dr. D. Reeve, Canada Centre for Mineral and Energy Technology,  
Director: Department of Energy Mines and Resources, 555 Booth Street, Ottawa,  
Ontario, K1A 0G1. 613-995-4060



Task: Renewable Energy  
Program: Biomass Energy  
Subprogram: Conversion Technologies (Sheet 4 - Direct Combustion)

#### OBJECTIVE

To determine the feasibility and economics of biomass-fired heating and drying systems.

#### WORK

In 1978-79 four contracts dealing with direct combustion were let. One dealt with the economic and technical feasibility of installing a wood-fueled boiler system at the Great Lakes Forest Research Centre, Sault St. Marie. A contract in Cape Breton explored the technical and economic feasibility of making a substantially sized sawmill energy self-sufficient as well as marketing a desified biomass fuel. A study was made of the availability of hog fuel in the south coastal zone in British Columbia. The design and construction of a new bark dewatering device was funded.

In 1979-80 work on the above was continued.

For funding see 4.3.6 (Sheet 1)

Subprogram Dr. R.P. Overend, Energy Project, National Research Council, Bldg. M-50,  
Director: Montreal Road, Ottawa, Ontario, K1A 0R6 613-993-3405

1978-80

Task: Renewable Energy

Program: Biomass Energy

Subprogram: Biomass Fundamental Studies (Sheet 1 - Anaerobic Conversion of Cellulose to Methane)

#### OBJECTIVE

To conduct fundamental studies of the conversion of cellulose and other biopolymers to methane by anaerobic bacteria.

#### WORK

The work involves:

- Selection of a microbial ecosystem capable of degrading cellulosic materials to methane; its maintenance and stabilization in a defined medium to study the nutritional and fermentation conditions and to optimize the process.
- Examination of the symbiotic involvement of various anaerobes in the ecosystem; the biochemical balance between their activities and conditions affecting their symbiotic interaction;
- Isolation, characterization and nutritional requirements of fastidious anaerobes present in the ecosystem;
- Study of the intermediary metabolism of methanogenic bacteria, particularly with respect to the conversion of acetate, CO<sub>2</sub> and H<sub>2</sub> to methane.

The funds below are for all of Subprogram 4.3.7

78-79 Funds: \$322,000

79-80 Funds: \$401,000

Subprogram Dr. S.A. Martin, Biological Sciences, National Research Council,  
Director: Montreal Road, Ottawa, Ontario, K1A 0R6 613-992-2367

1978-80

Task: Renewable Energy  
Program: Biomass  
Subprogram: Biomass Fundamental Studies (Sheet 2 - Fermentation of Pentoses)

#### OBJECTIVE

To genetically modify yeasts to allow them to ferment efficiently pentoses as well as hexoses.

#### WORK

Recombinant DNA techniques are used. The work consists of introducing into yeasts appropriate genes from other organisms which can already ferment pentoses. This may lead to solution of the practical problem of improving alcohol yields during fermentation.

The work is being carried out in a molecular genetics group which has in progress several other recombinant DNA projects involving yeasts.

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For funding see 4.3.7 (Sheet 1)

Subprogram Dr. A.P. James, Biological Sciences, National Research Council, Montreal  
Director: Road, Ottawa, Ontario, K1A 0R6 613-992-7833

1978-80

Task: Renewable Energy  
Program: Biomass  
Subprogram: Biomass Fundamental Studies (Sheet 3 - Microbial Strains for Energy Production)

#### OBJECTIVE

To construct strains of E. coli which contain a highly active hydrogenase activity.

#### WORK

The work involves cloning the gene for the hydrogenase from D. desulfuricans into an E. coli plasmid. The availability of cloned hydrogenase genes may allow the construction of more efficient nitrogen fixing organisms. The increased amounts of enzyme made available may facilitate the development of cell-free systems for the production of hydrogen.

For funding see 4.3.7 (Sheet 1)

Subprogram Dr. W.G. Martin, Biological Sciences, National Research Council,  
Director: Montreal Road, Ottawa, Ontario, K1A 0R6 613-992-6512

1978-80

Task: Renewable Energy  
Program: Biomass Energy  
Subprogram: Socio-Economic-Technical Studies and Information

#### OBJECTIVE

To reference scientific and technical information for researchers and entrepreneurs.

#### WORK

The process of technology transfer from the R&D program through to the demonstration phase and out to the public is accomplished by publications, contractors' review meetings and the preparation of indepth technical reviews of specific R&D objectives in biomass R&D.

Publication of a bi-monthly newsletter is being supported to improve the public's awareness of the attainability and relative economics of renewable options. Additionally, a public awareness program is being developed relative to the utilization of forest biomass in meeting Canada's energy requirements.

The technology transfer activity is being launched via an annual workshop designed to achieve information exchange among contractors, scientific authorities, and the Canada Institute of Scientific and Technical Information.

78-79 Funds: \$198,000

79-80 Funds: \$273,000

Subprogram Dr. R.P. Overend, Energy Project, National Research Council, M-50,  
Director: Montreal Road, Ottawa, Ontario K1A 0R6 613-993-3405



1978-80

Task: Renewable Energy  
Program: Wind Energy  
Subprogram: Wind Energy Resource Assessment

#### OBJECTIVE

To assess and quantify the Canadian wind energy resource.

#### WORK

Assessment of the wind energy resource distribution has been largely undertaken by the AES of DOE. Work to date has concentrated on the reduction of existing archival data to a standard height of 10 metres, and on the development of methods for assessing wind energy potential at sites where local terrain effects are important. AES are also representing Canada on the OECD/IEA Implementing Agreement for a Program of Research and Development on Wind Energy Conversion Systems, Annex II, - an international activity on the evaluation of computer models for wind energy siting.

The NRC Wind Prospecting project obtains wind speed measurements at selected sites in different parts of Canada, specifically chosen for their wind energy potential (in conjunction with electric utilities and other potential user groups). Equipment has been procured and will be installed at chosen sites during 1980-81.

78-79 Funds: \$204,000

79-80 Funds: \$330,000

Subprogram Mr. R.J. Templin, Low Speed Aerodynamics Laboratory, National Research  
Director: Council, Ottawa, Ontario, K1A 0R6 613-993-2423

1978-80

Task: Renewable Energy  
Program: Wind Energy  
Subprogram: Technical Development of Small (< 100 kW) Vertical Axis Wind Turbines  
(Sheet 1 - Grid Coupled Electrical Generation)

#### OBJECTIVE

To develop VAWT technology and to demonstrate its applications.

#### WORK

During 1977-78, the design and construction of two 50-kW VAWT's was contracted to a Canadian company, and they were delivered in 1978-79. By agreement with the respective provincial power utilities, these two wind turbines have been erected and are operating in the automatic grid-coupled mode at Holyrood, Newfoundland and near Swift Current, Saskatchewan. Operational trials are continuing.

VAWTG's will be installed in 1980-81, at Victoria, B.C. and at Churchill, Man. These projects are also joint ventures with provincial utilities and research agencies, and are aimed at obtaining operating experience which will allow the utilities to assess VAWTG's as grid-scale generation devices, as well as determining performance and operational feedback for the Wind Energy R&D Program.

An older 50 kW grid-coupled VAWT is to be refurbished to current standards and erected at the Atlantic Wind Test Facility on Prince Edward Island for extensive performance and durability tests.

The funds below are for all of Subprogram 4.4.2

78-79 Funds: \$955,000

79-80 Funds: \$750,000

Subprogram Mr. R.J. Templin, Low Speed Aerodynamics Laboratory, National Research  
Director: Council of Canada, Ottawa, Ontario, K1A 0R6 613-993-2423

Task: Renewable Energy  
Program: Wind Energy  
Subprogram: Technical Development of Small ( $<100$  kW) Vertical Axis Wind Turbines  
(Sheet 2 - Remote Electrical Generation)

#### OBJECTIVE

To develop vertical axis wind turbine (VAWT) technology for electricity generation at remote sites.

#### WORK

There are a significant number of isolated communities, especially in Northern Canada, whose electricity is provided from local diesel generators. The fuel for these units is very expensive and supply interruptions could have serious consequences. A VAWT/diesel hybrid generation system can significantly reduce the requirement for diesel fuel while still providing on-demand power. Tests on a preliminary 10 kW test unit were completed in 1978-79 and results warranted design, fabrication, and evaluation of a 100 kW prototype unit. This project will be initiated in 1980-81 as a joint venture between NRC, Ontario Hydro, and various interested federal and provincial agencies.

Another Canadian company has developed a series of VAWTG's with direct-drive generators and battery storage systems for stand-alone aeroelectric power supplies for telecommunications relay stations, navigational beacons, etc. Four units with ratings up to 3 kW have been erected in conjunction with various communications companies, and two more units will be installed in 1980-81. Design and experimental development is continuing with financial support from the Industrial Programs Office of NRC.

For funding see 4.4.2 (Sheet 1)

Subprogram Mr. R.J. Templin, Low Speed Aerodynamics Laboratory, National Research  
Director: Council of Canada, Ottawa, Ontario, K1A 0R6 613-993-2423

1978-80

Task: Renewable Energy  
Program: Wind Energy  
Subprogram: Technical Development of Small ( $< 100$  kW) Vertical Axis Wind Turbines  
(Sheet 3 - Non-Electrical Applications)

#### OBJECTIVE

To examine the potential for non-electrical applications of VAWT's.

#### WORK

The only work performed during 1977-78 was the construction by a Canadian manufacturer, without federal financial support, of a wind turbine for sale to the U.S. Department of Agriculture for tests as an irrigation water pumper at a site in Texas. The aerodynamic configuration of this turbine is the same as that of the 50-kW turbines referred to in 4.4.2 (Sheet 1). Operational field trials by the United States Department of Agriculture have been successful to date and are continuing.

For funding see 4.4.2 (Sheet 1)

Subprogram Mr. R.J. Templin, Low Speed Aerodynamics Laboratory, National Research  
Director: Council of Canada, Ottawa, Ontario, K1A 0R6 613-993-2423

Task: Renewable Energy

Program: Wind Energy

Subprogram: Technical Development of Large (> 100 kW) Vertical Axis Wind Turbines

## OBJECTIVE

To apply megawatt-scale VAWT technology in electric utility systems.

## WORK

The largest single hardware project in progress is the joint operation by NRC and Hydro Quebec of the 230 kW VAWT on the Magdalen Islands. It was designed for fully automatic operation, directly connected to the 36 MW all- diesel Magdalen Island system, to which it fed energy from initial operation in July 1977 until an accident in July 1978 destroyed the rotor. Subsequent investigation showed that the accident was not caused by design or structural deficiencies in the rotor, and in fact showed that the rotor and guy cables remained intact during about one hour of operation at about twice the design speed. At the time of the accident, the original turbine had operated successfully at speeds up to 80 percent of rated speed and power measurements showed that electric power output exceeded theoretical estimates. A replacement rotor to the same design has been built and was erected in late 1979-80. Testing is scheduled to continue throughout 1980-81, and the machine will then be turned over to Quebec Hydro for automatic operation as part of the Magdalen Islands electricity supply system.

During 1978-79, a contract was awarded to an industrial group for a study to provide industrial cost estimates of production vertical-axis turbines over a size range from somewhat larger than the Magdalen Islands turbine to about 10 megawatts. The study, which included assessment of problems of transportation and erection, was completed in October 1978. It concluded that there were no technical obstacles to development, and also that the total costs, per unit of energy produced, continue to decrease with increasing size throughout the size range studied. Methods of proceeding toward the design and construction of a prototype turbine of swept area about 4000 m<sup>2</sup>, with installed power in the low megawatt range, were the subject of a Project Definition study by the same group in 1979. Extensive consultations have taken place with the Energy Policy and Electrical groups at EMR, and a program proposal for the prototype project is now being developed. The size of the proposed prototype may be compared with the largest U.S. horizontal axis turbine, the NASA-Boeing MOD-2 (swept area = 6560 m<sup>2</sup>, installed power = 2.5 MW), which is now in the advanced design stage.

NRC and EMR also participated in an extensive study commissioned by Hydro Quebec to compare generically the horizontal axis and the vertical axis wind turbine configurations for megawatt-scale electrical generation. The results of this study will be published early in 1980-81 and will confirm the VAWT is at least competitive and indeed may be technically and economically superior to the HAWT in this application.

78-79 Funds: \$560,000

79-80 Funds: \$765,000

Subprogram Mr. R.J. Templin, Low Speed Aerodynamics Laboratory, National Research  
Director: Council of Canada, Ottawa, Ontario, K1A 0R6 613-993-2423



Task: Renewable Energy  
Program: Geothermal Energy  
Subprogram: Delineation of Regional Geothermal Anomalies

## OBJECTIVE

To acquire and interpret geological and geophysical data from all parts of Canada, particularly the cordillera, in order to identify those areas most likely to have potential for geothermal development.

## WORK

All efforts specifically aimed at potential geothermal energy resources under this subprogram have so far been located in British Columbia, both in the belts of recent volcanism in the Coast Range and in areas of suspected thermal anomaly in the interior plateau. This work benefits from and proceeds in parallel with continuing studies of geological structure, volcanic history and hot-spring-geochemistry by the Geological Survey, EMR and studies of geothermal flux, crustal temperature and radioactive heat generation by the Earth Physics Branch, EMR. This geothermal energy program received its starting impetus from these long-term scientific activities.

Since 1976 detailed geological and geophysical studies of known volcanic centres have provided new information on the age and history of volcanic events, needed to assess the suitability of these centres for detailed study.

The heat production by radioactive trace elements and by potassium in intrusive igneous rocks creates high temperature gradients and zones of hot dry rock, lacking the water supply and the extreme temperatures necessary for the formation of hydrothermal systems. Continuing measurement of heat production of rocks and shallow drilling of intrusive rock masses is yielding information on the geothermal potential, but this work is in a very early stage. It is still possible for high temperature gradients to be detected unexpectedly in the course of routine measurements in holes drilled for mineral exploration.

Contracts have been let for geological and geophysical work; these include:

- diamond drilling for temperature surveys in the coryell syenite intrusives
- radioactive age determination of extrusive centres
- maintenance of hot-spring inventory and sample analysis
- chemical analysis of extrusive rocks and hot spring waters
- geological mapping of large volcanic features
- diamond drilling of selected tertiary intrusive bodies
- review of existing data of granitic bodies in Maritime provinces

As the exploration and development of specific geothermal sites is taken up by provincial utilities and industrial agencies, a greater proportion of the federal effort is expected to be concentrated in regional studies, in the western mountains and in the Maritime provinces and in the sedimentary basins.

78-79 Funds: \$73,000

79-80 Funds: \$148,000

Subprogram Dr. Alan M. Jessop, Earth Physics Branch, Division of Seismology and  
Director: Geothermal Studies, Department of Energy Mines and Resources,  
1 Observatory Cres., Ottawa, Ontario K1A 0Y3 613-995-5490

Task: Renewable Energy  
Program: Geothermal Energy  
Subprogram: Identification and Assessment of Geothermal Resources

## OBJECTIVE

To assess the potential of selected geothermal areas for the encouragement of geothermal energy exploitation within Canada.

## WORK

Meager Mountain was selected in 1974 as the first target for detailed study for the purpose of demonstrating the existence of geothermal resources in the Canadian volcanic regions. This decision was made independently by EMR and by B.C. Hydro, and the two agencies have worked in a cooperative manner since that time. The first project, drilling near the Meager Creek hot spring was done by EMR, and the escaping energy has been traced back towards its source until in 1979 a drill penetrated into the apparent roof of a reservoir zone and temperatures up to 202°C were recorded. The administrative format has now changed from an informal cooperation between the two agencies, with each taking responsibility for parts of a continuing program, to a system of full responsibility by B.C. Hydro with partial funding from a federal-provincial source and technical direction from a committee of federal and provincial personnel.

Up to six additional (and deeper) test holes were planned for Meager mountain in 1979-80. During 1979-80 small contracted studies are being carried out in informal cooperation with B.C. Hydro and Power Authority. These include:

- petrological studies of core from previous years
- fission-track dating of core
- trace element surveys
- isotope hydrology of Meager Mountain area

The data now available from the Meager Mountain area show that hydrothermal systems exist on the south side and probably also on the north side of the volcanic complex. The region in the central part is still relatively unknown, since the rugged terrain and high elevations make geophysical surveys difficult and expensive. By 1981 the work should be sufficiently advanced for the drilling of the full-size proving and production wells on the south side. Identification work will then be redirected to the north side of Meager Mountain and will be accelerated at Mt. Cayley, some 60 km to the south.

78-79 Funds: \$239,000

79-80 Funds: \$460,000

Subprogram Director: Dr. Alan M. Jessop, Earth Physics Branch, Division of Seismology and Geothermal Studies, Department of Energy, Mines and Resources, 1 Observatory Cres., Ottawa, Ontario K1A 0Y3 613-995-5490

1978-80

Task: Renewable Energy  
Program: Geothermal Energy  
Subprogram: Geothermal Energy from Sedimentary Basins

## OBJECTIVE

To assess and demonstrate the potential low-grade geothermal resources located in sedimentary formations for future space-heating and other direct heat applications.

## WORK

A regional assessment of the geothermal potential of warm (50°-175°C) water in the sedimentary rocks below the prairie provinces was commenced in 1975. It was shown that the energy resource is very large, equivalent to  $8 \times 10^{12}$  barrels of oil, but it is widely spread, probably only economically useful close to the well that produces it, and possibly subject to difficulties related to dissolved salt content. Early in 1977 the University of Regina expressed interest in a pilot study, and there followed a detailed study of the Regina-Moose Jaw area. When the results of this study were seen to be favourable, a well was drilled to 2214 metres on the campus of the university.

Extensive testing at the well has taken place, including a variety of logging, including temperature logs, pumping tests, hydrofracturing, and chemical analysis of the formation water. Results show that permeabilities and porosities of the target formations are good and that temperature is probably slightly below the predicted value. Further tests will be carried out during 1980, including further temperature logging and tests on the corrosive properties of the water.

Further regional work is progressing, aimed at delineating the most favourable regions for geothermal development. It has been shown that a very large energy resource exists, but that it is at a low temperature and is best used for space heating or other direct heat applications. The widespread distribution of the source and the possible corrosive qualities of the water must be overcome by potential users.

78-79 Funds: \$730,000

79-80 Funds: \$221,000

Subprogram Director: Dr. Alan M., Jessop, Earth Physics Branch Division of Seismology and Geothermal Studies, Department of Energy Mines and Resources, 1 Observatory Cres., Ottawa, Ontario, K1A 0Y3 613-995-5490

TASK 5  
ENERGY TRANSPORTATION AND TRANSMISSION

## Introduction to TASK 5: ENERGY TRANSPORTATION AND TRANSMISSION

The transportation of energy commodities and the transmission of electric power are major components of any energy supply system and are necessarily related to energy policy and the comparative economics of various energy supply options. This Task has been divided into two Programs: the transportation of energy commodities (coal, oil and gas) by any means such as pipeline, ship or rail; and the transmission and distribution of electrical energy.

The overall Task Coordinator is:

Mr. N. Gore  
Strategic Studies, Transport Canada  
Podium Building, 4th Floor  
Place de Ville  
Ottawa, Ontario  
K1A 0N5

613-996-4636

The Task is divided into two Programs:

### 5.1 Energy Commodities

The extensive exploration program and resulting anticipated delivery of Arctic oil and gas has greatly influenced the emphasis of this Program. Arctic factors, which are the subject of energy transportation requirements include system studies (5.1.1), marine transport support systems (5.1.2), arctic class vessel performance (5.1.3), vessel design, propulsion and ancillary systems (5.1.4), and ice research, bathymetry and oceanography (5.1.5). Subprogram (5.1.6) concentrates on the expected large increase of east-west flows in southern Canada. The remainder of this Program looks at hazardous commodities (5.1.7), pipeline technology applications (5.1.8) and transport of other energy commodities (5.1.9).

The Program Convener is:

Mr. N. Gore  
Strategic Studies, Transport Canada  
Podium Building, 4th Floor  
Place de Ville  
Ottawa, Ontario  
K1A 0N5

613-996-4636

### 5.2 Transmission and Distribution of Electricity

Federal support of this Program takes two forms:

- Funding and advisory support of the Canadian Electrical Association. The CEA's Research and Development Advisory Committee received about one-third of its 1979 funding from the federal government. The studies initiated by the Committee are provided in this document (5.2.1).



- Work done in-house and contracted out by the Division of Electrical Engineering of the National Research Council. This includes fundamental cryogenic research (5.2.2), high voltage direct current transmission (5.2.6), dielectric insulation (5.2.7), high voltage impulse measurements and standards (5.2.8) and measurement of electric power, energy and related quantities (5.2.9).

The Program Convener is:

Mr. A. Scott  
Energy Policy Sector  
Energy, Mines and Resources  
580 Booth Street  
Ottawa, Ontario  
K1A 0E4

613-995-9351.

1978-80

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Frontier System Studies (Sheet 1 - Marine Transportation of Oil & Liquefied Natural Gas from the Arctic)

#### OBJECTIVE

To assess the technical and economic feasibility of transporting oil and LNG from the Arctic to markets in southern Canada by a predominantly marine mode.

#### WORK

The first phase of a feasibility study to assess the technical and economic feasibility of transporting oil and LNG from the Arctic Islands to southern markets was completed in 1978-79.

While the results of the study concluded that the year-round transport of oil and LNG by the marine mode was technically feasible, a number of technical factors and uncertainties that require further research were identified. Cognizance was taken of many of the technological factors that were identified as candidates for additional research and were incorporated to the maximum extent practicable in developing the energy-related marine transport R&D program for 1979-80 and 1980-81.

Work on the second phase of this study began in 1979-80 and extends into 1980-81. A more rigorous economic analysis is being carried out, in which some of the broad assumptions used in the analysis are being more clearly defined. Several cost/benefit studies are planned to help establish the extent to which the federal government might be required to provide financial assistance and infrastructure in support of a marine transport system.

The funds below are for all of subprogram 5.1.1

78-79 Funds: \$88,000

79-80 Funds: \$143,000

Subprogram Director: Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building, 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636

1978-80

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Frontier System Studies (Sheet 2 - Harbours; Arctic Marine Technology; Program Development; and Energy Flows)

## OBJECTIVES

To undertake whatever studies (outside of 5.1.1 Sheet 1) are necessary to provide an overview of systems requirements and developments for the transportation of energy commodities.

## WORK

Four components are described on this sheet:

- Evaluation of Potential Port and Harbour Sites. The work involves the identification and assessment of potential marine terminal sites in the Arctic. Variables observed include beach profiles, local bathymetric data, geological conditions and availability of fresh water. A coastal reconnaissance and field investigation was started in 1976 to identify and evaluate areas in the central and eastern Arctic Archipelago. A report on the southern portion of the study area is available through the GSC. Initial field work of potential sites in the Sverdrup Basin were carried out in 1978-79. This project is managed by the GSC, EMR, with coordination by Strategic Studies Branch, Transport Canada.
- Development of an Arctic Marine Technology Program. An assessment has been made of the technological requirements needed for vessels suitable for full Arctic operations. The state of technology of each of the principal marine system performance categories that were studied. These included ice transitting performance, hull structural integrity, propulsion system and appendage performance and hazard detection/collision avoidance. Cost estimates, schedules and plans for 16 R&D programs, which in turn consisted of numerous research projects, were developed. This project is managed by the Technology Development Branch, Transportation Development Centre, with coordination by Strategic Studies Branch, Transport Canada.
- Energy R&D Program Development. Participation in the activities of the Marine Transport and other modal advisory Boards, particularly rail and highway, will also provide important contributions to the Arctic marine components of Program 5.1 as well as to the transport of coal and dangerous commodities Subprograms.
- Future Energy Flows and Energy Transportation Requirements. This work identifies energy resource development options, examines the probable range of inter-regional energy flows which would develop in Canada over the period 1980-2000 and identifies the transportation system requirements and costs needed to accommodate these flows. This is an on-going in-house activity by the Strategic Studies Branch.

For funding see 5.1.1 (Sheet 1)

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada,  
Director: Podium Building, 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5.  
613-996-4636

1978-80

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Marine Transport Support Equipment Development

## OBJECTIVE

To ensure the availability of adequate technology for the support systems of Arctic marine energy commodities transport.

## WORK

- Remote Sea-ice Thickness Sensor. An airborne sensor is being developed to remotely measure sea-ice thickness in the immediate vicinity of a ship for tactical purposes and in the general Arctic and along potential shipping lanes to provide strategic information for ice forecasting and route planning. A combined impulse/synthetic pulse radar system has been developed and controlled laboratory tests will be followed by an operational prototype to be designed with construction and initial field trials planned for 1980-81.
- Collision Avoidance and Hazard Detection. A study to analyse the types of marine ice hazards and hazard detection systems will help in the selection of sensing devices for experimental evaluation. The system must have a capability of detecting icebergs or growlers down to a size of 5 metres cubed (125 cubic meters) at ranges between 5 and 15 kilometres from a ship. This will result in an experimental evaluation project.
- High Intensity Light Source. A prototype system involving a vortex-stabilized plasma high intensity light source has been developed for shipboard use to meet a Coast Guard requirement during periods of darkness. The system consists of the light source with a reflector and cooling system suitably packaged for installation on the mast of a ship, and a portable power supply and control system. The lamp is capable of providing approximately 60 kW of useful adiated power. Further work is aimed at an operational systems.
- Navigation and Communication Equipment. While various world-wide or extended-range systems, such as Omega, Loran C and satellite positioning systems operate satisfactorily in southern latitudes, the accuracy degrades in the higher latitudes of the Arctic where the electronic signals may be affected by the diurnal cycle, atmospheric conditions, sea ice and distance from the ground transmitting stations. This project seeks to overcome these problems. As a first stage, this work will include a state-of-the-art study to define research projects which can be clearly defined to avoid duplication of effort.

These projects are being managed by the Technology Development Branch, Transportation Development Centre, with coordination by the Strategic Studies Branch, Transport Canada.

78-79 Funds: \$297,000

79-80 Funds: 215,000

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building,  
Director: 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Arctic Class Vessel Performance

## OBJECTIVE

To obtain full scale data on the performance of vessels with an ice-breaking capability; to determine the effect of various bow forms and hull design parameters on vessel performance in ice and open water.

## WORK

Two components are described on this sheet:

- Evaluation of Icebreaker Performance. The Canadian Coast Guard Ship Louis S. St. Laurent has been instrumented to evaluate the effectiveness of low friction paint. In a related project, laboratory tests were carried out to measure the static and kinematic coefficients of friction between fresh water and laboratory grown saline ice and samples of ship hull steel that were uncoated and coated with three types of low friction coatings.

A newly commissioned Class III icebreaker, the Canadian Coast Guard Ship Radisson has been instrumented for trials under various ice conditions.

Examination is under way of a proposed Class IV icebreaker.

- Analysis of Hull Shapes and Forms. A model test program to evaluate the effect of various hull shapes on icebreaker performance in level ice, at several ice thickness and speeds of advance is being carried out. Parametric studies will assess the effect of bow slopes and angles, flare at the forward, midbody and aftbody of the vessel as well as other vessel parameters such as beam, length, and draft on performance in ice and open water. Analytical data will be related to available full scale and model test data.

These Projects are being managed by Fleet Systems, Canadian Coast Guard, with coordination by the Strategic Studies Branch, Transport Canada.

78-79 Funds: \$479,000

79-80 Funds: \$358,000

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building,  
Director: 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636



1978-80

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Vessel Design, Propulsion and Ancillary Systems (Sheet 1 - Hull Design and Strength)

## OBJECTIVE

To assess the adequacy of the regulatory and design criteria for Arctic class vessels as currently promulgated in the CASPPR and to amend them as may be required; to investigate new or innovative technologies related to ship propulsion and ancillary systems for application to icebreakers or ice-breaking cargo vessels.

## WORK

Three components are described on this sheet:

- Force and Acceleration Spectrum for Icebreaking Vessels. This is the development of a basic ship-ice dynamic interaction computer simulation model to estimate the forces and accelerations encountered by an icebreaker. The initial study consisted of mathematical simulation, physical model testing in saline and synthetic ice and comparison with full scale data. Ice interaction modes investigated included continuous icebreaking, ramming in thick level ice, oblique impact with ice floes, jamming between floes and collisions with large ice features such as an iceberg.
- Structural Steel Standards for Arctic Class Vessels. This work is for steel and welding standards for low temperature operation. The initial work includes
  - definition of the environmental conditions
  - development of a modelling technique to analyze heat flow and temperature gradient
  - review of low temperature steel properties, specifications and test methods; select or devise appropriate specifications, tests, etc.
- Hull Structural Strength Requirements. Current regulatory requirements, as defined in the pollution prevention regulations, for the hull structural strength requirements of Arctic class vessels are being evaluated to update or confirm their adequacy. Particular attention will be made to the needs of ships with high momentum. Work will include theoretical studies and analysis of hull-ice interaction, including the effects of friction, hull forms and ice fracture modes.

These projects are being managed by the Technology Development Branch, Transportation Development Centre, with coordination by the Strategic Studies Branch, Transport Canada.

The funds below are for all of Subprogram 5.1.4

78-79 Funds: \$87,000

79-80 Funds: \$443,000

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building,  
Director: 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636

1978-80

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Vessel Design, Propulsion and Ancillary Systems (Sheet 2 -  
Propulsion Systems)

## OBJECTIVE

To obtain technical data to assist the Ship Inspection Branch of the Canadian Coast Guard to confirm or modify existing rules governing the design of propellers and propeller shafts for Ice Class Vessels; to confirm or modify regulatory criteria for power requirements; and to investigate alternative propulsion systems.

## WORK

Three components are described on this Sheet.

- Ice Class Propellers and Propeller Shafts. A comparative study is being conducted into the rules of the various Classification Societies covering the design of ice class propellers and shafts. This work will be supplemented by discussions with major manufacturers of propellers to obtain their views, based on experience, on the adequacy or otherwise of the regulations governing the design of propellers and shafting. Another study will assess various devices or systems to minimize or prevent propeller contact with ice, such as propulsion nozzles, ice deflectors and gratings. Also, the work will study the effects of vessel draught and propeller submergence, estimate the effects on propulsive efficiency, manoeuvring capability.
- Power Requirements for Arctic Class Vessels. Using the results of the work on prediction methods for forces encountered by ships, a mathematical model is being developed to estimate the resistance to the passage of a ship through various types of ice conditions. Propulsion system effectiveness, including arrangements for effective steering and control and devices to reduce resistance or augment thrust, are being investigated.
- Marine Propulsion Systems. A number of schemes are being considered for transmitting power from the prime mover to the propeller. A joint-participation project is evaluating a superconducting motor propulsion system. There is also an investigation into a two-stage epicyclic marine transmission gear box.

These projects are being managed by the Technology Development Branch, Transportation Development Centre, with coordination by the Strategic Studies Branch, Transport Canada.

For funding see 5.1.4 (Sheet 1)

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building,  
Director: 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636

GOVERNMENT OF CANADA

1978-80

Task: Energy Transportation and Transmission

Program: Energy Commodities

Subprogram: Ice Research, Bathymetry and Oceanography (Sheet 1 -  
Development of Real-Time Ice Prediction Model).

## OBJECTIVE

To develop a computerized ice status system, utilizing weather satellite imagery data; to develop models to predict ice motion and behaviour. This is in support of oil and gas transportation systems.

## WORK

The basic computer model for recording satellite imagery on a map has been further developed to determine the inverse mapping functions between the ice status data base and TIROS-N satellite imagery. Interpolation coefficients were developed to locate data points in the satellite image for use in the ice status classification system. A floe motion prediction procedure, taking into account inertial oscillations observed in the motion of ice floes, has been completed. Upon completion of a study on the effects of river outflow on flow motions, an initial evaluation of the prediction procedure will be carried out. A comprehensive literature survey on fast ice movement has been completed and the physical factors to be included in a prediction model have been identified.

An upgraded prediction model incorporating internal ice resistance computations was developed and tested in the laboratory and by IFC in the Beaufort Sea and the Gulf of St Lawrence. Research on the prediction of the motion of ice pack edge, freeze-up and break-up and the opening, closing and orientation of leads in pack ice is scheduled.

This project is being managed by the Atmospheric Environment Service, Fisheries and Environment Canada with coordination by the Strategic Studies Branch, Transport Canada.

The funds below are for all of Subprogram 5.1.5

78-79 Funds: \$1,127,000

79-80 Funds: \$725,000

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building,  
Director: 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636

1978-80

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Ice Research, Bathymetry and Oceanography (Sheet 2 - Development of Bathymetry Equipment).

#### OBJECTIVE

To develop improved equipment and techniques for bathymetric surveys in ice-covered waters, and the collection of related hydrographic data.

#### WORK

The development of year-round shipping operations in the Arctic necessitates the production of accurate and comprehensive hydrographic charts. Existing equipment is being improved and innovative techniques and equipment are being developed to obtain bathymetric and ice-thickness data, as well as tidal and tidal current data.

Work on this multi-year development program started in 1977-78. A prototype spike coupled acoustic transducer was developed, as well as a helicopter mounted deployment mechanism. Work also started on ice physics and acoustic propagation research in support of the design of new equipment to obtain ice thickness and bathymetry data simultaneously.

The prototype transducer and actuator system has been developed into an operational system. Work has begun on the development of related system components including sonar transceiver, data display, and data logger to be used in conjunction with the new transducer/actuator assembly.

More recently, work has been begun related areas including positioning systems, energy sources for remotely-located electronic equipment, air photo interpretation for near-shore bathymetry, the design study of an acoustic telemetry system for use with bottom mounted tide gauges and the study of tide propagation in the Arctic Archipelago. Development has begun of a submersible Arctic tide gauge.

This project is being managed by the Canadian Hydrographic Service, Fisheries and Oceans Canada with coordination by the Strategic Studies Branch, Transport Canada.

For funding see 5.1.5 (Sheet 1)

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building,  
Director: 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636



1978-80

Task: Energy Transportation and Transmission

Program: Energy Commodities

Subprogram: Ice Research, Bathymetry and Oceanography (Sheet 3 - Aerial Survey of Arctic Ice Conditions).

## OBJECTIVE

To obtain detailed information on ice-conditions during spring break-up and winter freeze-up in the Arctic region by a series of low level airborne photographic surveys. This is for the development of a year round Arctic Marine transport system.

## WORK

Information is being developed on ice conditions during the period when potential shipping channels are completely covered with ice; information is also being developed on summer break-up and winter freeze-up patterns and the movement of ice during these two periods.

In addition to standard parameters, information has been recorded on flow size and distribution by type and concentration, large scale movements of ice and ridge frequency. These data have been analysed in conjunction with satellite imagery to produce a series of nine detailed ice charts. Maps were prepared showing ice movements during June to October and ridge frequency by ice type in the spring and fall. Historic summaries of ice conditions, for 17 zones within the study area, were also prepared and presented in a series of tables and graphs showing estimated concentrations and thickness of old and first year ice, and the probability of old ice concentrations.

A preliminary transit model for a ship to "meander" through a mixed ice field, which was also developed, provided a novel approach to the problem of navigating vessels in the ice-infested waters of the Arctic.

This project was managed by the Atmospheric Environment Service, Fisheries and Oceans Canada with coordination by the Strategic Studies Branch, Transport Canada.

For funding see 5.1.5 (Sheet 1)

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building,  
Director: 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636



1978-80

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Ice Research, Bathymetry and Oceanography (Sheet 4 - Surface Survey of Arctic Ice Conditions; Acquisition of Climatic, Oceanographic and Sea-Ice Data).

#### OBJECTIVE

To increase the detailed knowledge of Arctic ice and climatic conditions as a necessary part of an Arctic marine transport system.

#### WORK

- Surface Survey of Arctic Ice Conditions. Characteristics such as thickness, snow cover, properties and size of first and multi-year ice ridges are being studied as they are major factors in the transit of a vessel in Arctic waters.

A surface survey of ice conditions along a potential shipping channel between Melville and Cronwallis Islands was carried out during the period March-April 1978. This was a joint federal government industry project. Tasks carried out included the measurement of ice thickness and snow cover along the route, recording of meteorological conditions, and measuring the orientation and the surface and subsurface profile of approximately 30 ridges. An experiment was also carried out to determine the frequency of occurrences of measureable changes in strain in the ice cover. An area of ice was carefully surveyed to provide ground truthing of several sensing devices installed in AES reconnaissance aircraft which overfly the area. The data gathered on ground truthing and ice strain measurements are being analyzed.

- Acquisition of Climate, Oceanographic and Sea-Ice Data. Oceanographic data has been collected in several Arctic locations during the period March-April 1978. To examine the magnitudes of tidal and others such as conductivity/temperature/depth data. A large variety of data on physical characteristics of ice, e.g., thickness, rate of growth and decay and chemical properties, etc., as well as wind and temperature is being confirmed using sensing devices such as SLAR, laser profilimeters. These devices have been developed for use on ice patrol aircraft and ultimately used in connection with a radar system on Bylot Island overlooking the entrance to Lancaster Sound to monitor the floe of sea-ice and icebergs. These data will be of direct interest to the AES ice prediction model and will provide useful information related to offshore drilling operations and commercial shipping operations in these waters.

These projects are being managed by Ocean and Aquatic Sciences, Fisheries and Oceans Canada, with coordination by the Strategic Studies Branch, Transport Canada.

For funding see 5.1.5 (Sheet 1)

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building,  
Director: 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636

1978-80

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Coal Transportation

## OBJECTIVE

To ensure the availability of an adequate and efficient coal transportation network in Canada for the projected energy/coal flow demands.

## WORK

Three components are described on this Sheet.

- System Studies. Existing and anticipated technology offers a number of transport methods for movements, from western to central Canada, of thermal coal or coal-derived energy. The economics of such alternatives (unit trains, slurry pipelines, gasification, electrification) are being investigated. Institutional factors affecting all elements of a coal energy transportation system are also being investigated. Work is also proposed on transportation networks, both in the collecting and distributing areas.
- Evaluation of Steerable Rail Trucks. Preliminary studies by others have indicated that steerable rail trucks reduce fuel consumption and rail and wheel wear. Work is now being conducted to confirm and quantify these benefits before undertaking any large scale conversion connected to the mass movement of coal. This is a joint federal industry project.
- Slurry Pipelines. A contract to the Saskatchewan Research Council has resulted in construction and use of a 20 inch diameter test loop. Western thermal coals are being tested in this loop. Using test results, the economic feasibility of supplying coal via a pipeline to steam raising plants within heavy oil fields will be evaluated. This work is coordinated with that being conducted by the CANMET laboratories on the effects of slurry transport on coal beneficiation, combustion and carbonization. An investigation of a coal-in-methanol slurry is proposed.

78-79 Funds: \$2,000

79-80 Funds: \$419,000

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building,  
Director: 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Transportation, Storage and Transfer of Hazardous Energy  
Commodities

## OBJECTIVE

To provide the information to improve and develop standards for the safe handling of hazardous energy commodities.

## WORK

Two components are described on this sheet:

- Overland Transportation. Work carried out earlier identified several areas requiring further research. In-house work started on the hazard analysis of cryogenic fuel transportation. Further studies will involve:
  - study of transportation environment and establishment of a risk simulation model for the transport of cryogenic fuel gas. The study will be followed by calibration of the model.
  - assessment of the risk of increased distribution of compressed gaseous fuels to the residential energy market.
- LNG Terminals. This study provides the background required for assessing the adequacy of existing safety related standards governing the design, construction and operation of LNG terminals and for developing, as may be required, additional regulatory framework.

These projects are being managed by the Transport of Dangerous Commodities Directorate, Transport Canada, with coordination by the Strategic Studies Branch.

78-79 Funds: \$8,000

79-80 Funds: \$122,000

Subprogram Mr. N. Gore, Strategic Studies, Transport Canada, Podium Building,  
Director: 4th Floor, Place de Ville, Ottawa, Ontario K1A 0N5. 613-996-4636

1978-80

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Pipeline Technology Applications (Sheet 1 - Internally Insulated Pipeline).

#### OBJECTIVE

To identify and solve the anticipated scientific and engineering problems with respect to internally insulated conventional steel pipeline for short to intermediate distance transport of liquid natural gas.

#### WORK

Investigations on operating parameters for short and intermediate distance internally insulated LNG pipelines were covered earlier under an extension of the contract for technology assessment of long distance LNG pipeline. A sensitivity analysis was performed on a large number of design parameters for the above mentioned line in order to assess their influence on operating parameters of the line. Recommendations were provided on the scope of future work required to assess the concept of internally insulated LNG pipelines.

The funds below are for all of Subprogram 5.1.8

78-79 Funds: \$773,000

79-80 Funds: \$811,000

Subprogram Director: Dr. R. Thomson, Canadian Metals Testing Laboratory, Department of Energy Mines and Resources, 555 Booth Street, Ottawa, Ontario, K1A 0G1. 613-995-4044.

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Pipeline Technology Applications (Sheet 2 - Natural Gas Transmission).

#### OBJECTIVE

To evaluate candidate line-pipe steels for transmission of natural gas from Arctic fields.

#### WORK

The work identified on this sheet has involved characterization of pipe homogeneity and residual stress distribution, determinations of weldability, fracture toughness, corrosion fatigue and stress corrosion cracking resistance, effects of mechanical damage on fracture and other related aspects. Two current requirements to supplement the in-house requirements, as described above, were identified and started in 1978-79.

- Conventional fracture toughness tests have proven unsatisfactory in the characterization of low temperature toughness of HSLA line-pipe steels. Dynamic toughness test involving primarily instrumented specimens have been successful in this respect. A program has been developed to:
  - evaluate the correlation between top and specimen instrumentation in dynamic toughness tests of a Canadian produced line-pipe steel; and
  - effect technology transfer of this recent development in fracture toughness testing.
- A 3-phase program has been designed to evaluate the hot working of steels containing Mo and Nb for HSLA line-pipe.

Phase 1 (1978-79) effects of microalloying elements in solution on recrystallization

Phase 2 (1979-80) solute and precipitate effects

Phase 3 (1980-81) effects of processing conditions on metallurgical structure.

For funding see 5.1.8 (Sheet 1)

Subprogram Director: Dr. R. Thomson, Canadian Metals Testing Laboratory, Department of Energy Mines and Resources, 555 Booth Street, Ottawa, Ontario, K1A 0G1. 613-995-4044.



1978-80

Task: Energy Transportation and Transmission  
Program: Energy Commodities  
Subprogram: Transport of Other Energy Commodities.

#### OBJECTIVE

To ensure availability of technology for transportation of energy commodities other than oil, gas or coal. In this case, the focus is on wood; in particular the development of improved methods of transporting wood chips.

#### WORK

Federally-funded work began in 1978-79 with modest funding aimed at lowering the cost of transporting wood chips by:

- reducing loading and unloading time
- increasing the density (compacting) for transport
- improving towing techniques
- setting standards and regulations for large vehicles carrying chips on public routes.

Subprogram Director: Dr. R. Thomson, Canadian Metals Testing Laboratory, Department of Energy Mines and Resources, 555 Booth Street, Ottawa, Ontario, K1A 0G1. 613-995-4044.

Task: Energy Transportation and Transmission  
Program: Transmission and Distribution of Electricity  
Subprogram: Canadian Electrical Association (Sheet 1 - Transmission).

## OBJECTIVE

To improve the performance and reduce the cost and environmental impact of electrical transmission systems and substations.

## WORK

The federal government provides a portion of the total CEA budget. The projects are managed by the CEA.

The following specific areas of study are included in the program:

### Power Systems:

- Application of microprocessor technology to power systems.
- Further development of electric storm warning and tracking instruments and their application to major system control centres.
- Fundamental studies into the effects of large varying loads such as arc furnaces on power systems

### Transmission Systems:

- Further study of transmission and pipeline compatibility in joint-use of transmissions corridors.
- Study of AM radio signal re-radiation by transmission lines.
- Study of underground power transmission.
- Study of non-ceramic insulators.

### Substations and Equipment:

- Further studies on application of fibre optics technology in power systems.
- Development of a portable SF<sub>6</sub> decomposition by-product meter for use as a diagnostic tool.
- A study of metal oxide gapless arresters.

Funds shown below are the federal contribution, not the total CEA funds.

78-79 Funds: \$286,000

79-80 Funds: \$389,000

Subprogram Federal liaison with the CEA is by Mr. A.R. Scott, Energy, Mines and  
Director: Resources, 580 Booth Street, Ottawa, Ontario, K1A 0E4. 613-995-9351

1978-80

Task: Energy Transportation and Transmission  
Program: Transmission and Distribution of Electricity  
Subprogram: Canadian Electrical Association (Sheet 2 - Generation).

#### OBJECTIVE

To promote and develop new technologies including renewable energy resources for use in electrical generation.

#### WORK

The federal government provides a portion of the total CEA budget. The projects are managed by the CEA. The following four areas are covered:

- Fossil and Nuclear. This portion of the program includes a number of projects designed to improve reliability of generating systems through improved ability to anticipate failures and undertake scheduled maintenance. For example monitoring the condition of machinery is being improved through "signature analysis" to identify degradation of equipment performance. Other areas include metallurgical studies in material cracking, determination of residual stress and in improvement of welding processes. Environmental issues include the impact of emission control and the retrofit of a burner to reduce nitrogen oxide emissions from thermal stations.
- Hydraulic. A variety of studies includes cavitation, pitting damage of hydraulic turbines, ice cover in rivers and combination of wind generation and hydro.
- Alternate Energy Sources. Studies include the kinetics of peat and wood gasification and an evaluation of the current status of solar energy for electricity generation.
- Energy Management and Storage. This portion of the program is designed to find improved ways of meeting the time varying demands for electricity through a combination of improving system load factor and by seeking to identify and develop improved methods of energy storage.

Funds shown below are the federal contribution, not the total CEA funds.

78-79 Funds: \$562,000

79-80 Funds: \$469,000

Subprogram Federal liaison with the CEA is by Mr. A.R. Scott, Energy, Mines and  
Director: Resources, 580 Booth Street, Ottawa, Ontario, K1A 0E4. 613-995-9351.

1978-80

Task: Energy Transportation and Transmission  
Program: Transmission and Distribution of Electricity  
Subprogram: Canadian Electrical Association (Sheet 3 - Distribution).

## OBJECTIVE

To develop improved hardware for distribution systems; to improve the reliability and reduce environmental and social impact of electrical distribution systems.

## WORK

The federal government provides a portion of the total CEA budget. The projects are managed by the CEA. The following areas are covered:

- Distribution Poles. Several projects are exploring the improvement of wood poles for distribution systems including the use of new species and the treatment of poles with the object of reducing costs and extending life. work is also being undertaken on several designs of concrete and fibreglass reinforced poles to develop designs that would be suitable and economical for distribution systems. The primary object is to ensure the availability of satisfactory types of pole given the declining availability of the species of wood traditionally used for this purpose.
- Load Forecasting and Distribution. There continues to be need both in Canada and the United States for methodology for small area load forecasting. Modelling techniques are being applied to this problem. These are constrained by the quantity and quality of available national and local statistics. This form of forecasting is an essential element in developing more reliable forecasts on which ultimately the generation and transmission expansion programs will be based.
- 25 kV Distribution in Coastal Environments. This portion of the program is dealing with problems in 25 kV class distribution in areas subject to salt contamination. It is designed to ensure that this voltage level, which is particularly desirable for long rural lines, can be applied in coastal regions of Canada.
- Load Management. This work has significance to all four of the Subprograms in the CEA Research Program. The Distribution Subprogram is undertaking a number of projects and attempting to ensure coordination. In future, load management is likely to play an increasingly important role in ensuring the efficiency of planning for additions to generation and transmission systems as well as distribution development.

Funds shown below are the federal contribution, not the total CEA funds.

78-79 Funds: \$254,000

79-80 Funds: \$282,000

Subprogram Federal liaison with the CEA is by Mr. A.R. Scott, Energy, Mines and  
Director: Resources, 580 Booth Street, Ottawa, Ontario, K1A 0E4. 613-995-9351.

1978-80

Task: Energy Transportation and Transmission  
Program: Transmission and Distribution of Electricity  
Subprogram: Canadian Electrical Association (Sheet 4 - Utilization and Conservation).

#### OBJECTIVE

To improve the performance of customer equipment; to lead to more efficient use of electrical energy and better information on future requirements. It is designed, in addition, to lead to the substitution of less scarce resources via electricity for oil.

#### WORK

The federal government provides a portion of the total CEA budget. The projects are managed by the CEA. The following areas are covered:

- Residential Electric Heating. Several new programs are underway including studies of electricity distribution within the future residence, performance of residential electrical components, residential furnace efficiency and determination of energy required to produce hot water.
- Peak Load Management and Control. Two programs involving other sub-programs are being undertaken. In this Subprogram particular attention is being devoted to the impact of load management on the residential wiring system. Because peaking generation capacity tends to be oil-fired, the implementation of load management would reduce oil requirements for utilities in some situations.
- Use of Low Grade Heat. This program has sponsored work on combined generation of heat and electricity and is also sponsoring a demonstration project in the use of low grade heat in aquaculture. Another study is designed to determine heat losses from underground water pipes which might be used to deliver low grade heat for residential and commercial space and water heating purposes.
- Supply Reliability. A significant part of the investment in electric utility systems is designed to secure a high level of reliability in the supply to customers. Not enough is known of the effects of customer damage from electric service interruption and research is being undertaken in this area.

Funds shown below are the federal contribution, not the total CEA funds.

78-79 Funds: \$239,000

79-80 Funds: \$201,000

Subprogram Federal liaison with the CEA is by Mr. A.R. Scott, Energy, Mines and  
Director: Resources, 580 Booth Street, Ottawa, Ontario K1A 0E4. 613-995-9351.



Task: Energy Transportation and Transmission  
Program: Transmission and Distribution of Electricity  
Subprogram: Fundamental Cryogenic Research.

#### OBJECTIVE

To study the characteristics of insulating materials at very low (cryogenic) temperatures.

#### WORK

Short term tests have been conducted to determine the partial discharge (p.d.) and breakdown (b.d.) characteristics of polymeric insulation systems in liquid nitrogen containing butt gaps of various sizes are nearing completion. Two papers describing the results have been prepared.

Longer term tests to determine the exponent 'n' of the life curve ( $\text{Life} \times (\text{Voltage})^n = \text{Const}$ ) are being carried out and indicate that 'n' is greater than 30. The impulse strength (1.2/50 microseconds) has also been determined and switching surge tests are now underway.

The following tests are scheduled:

- completion of switching surge tests
- examination of the effect of repeated surges on the insulation performance
- determination of the effects of impurities on the short and long term breakdown strength of the insulation
- direct voltage tests to examine the effects of space charge accumulation
- tests at liquid helium temperatures

The test results indicate that the most suitable insulant for the use at cryogenic temperatures is a polypropylene paper laminate.

78-79 Funds: \$162,000

79-80 Funds: \$170,000

Subprogram Director: Dr. M.M.C. Collins, Division of Electrical Engineering, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R8.  
613-993-2669.

1978-80

Task: Energy Transportation and Transmission  
Program: Transmission and Distribution of Electricity  
Subprogram: High Voltage Direct Current Transmission.

#### OBJECTIVE

To study the power losses, radio interference, and audible noise of HVDC transmission.

#### WORK

Measurement of radio interference caused by corona on HVDC transmission lines at the HVDC test station (Albion Road, Ottawa) now includes RMS and Vd (dB difference between RMS and average) modes as well as QP. This has been done to reflect, for HVDC: the trend to encompass "communications" comparisons, as well as traditional "listener's response" comparisons

the increased mathematical strength of handling data

the possible inclusion of RMS/Vd requirements and testing procedures in Standards.

Differences from HVAC response, especially in foul weather, are being investigated.

Power loss caused by corona has been measured on full-scale HVDC lines, and checks well with that from test lines. It is hoped to pursue this investigation on full scale operating lines.

There is a need for "long term" (statistical) information on radio interference, audible noise, and power loss caused by corona on HVDC lines under a range of weather conditions. Statistical analysis of test station data is under way. It is planned to supplement this with data on operating lines. This involves a temporary (6 months to 1 year) on-site station at a location such as along the Nelson River (Manitoba) HVDC line, and involves cooperation with utility and industry. A comparison of the two will enable a better evaluation of the reliability of test line conclusions as applied to construction formula for new operating lines. It will also assist in the drafting of practical, reliable standards.

Work under this Subprogram also includes assistance to standards-writing organizations, utilities, etc. continues. The reliability of warning devices on mobil cranes approaching HVAC and HVDC lines was tested for DND. The devices were not reliable for HVDC. Suggestions were made for improving the reliability for HVAC.

78-79 Funds: \$195,000

79-80 Funds: \$160,000

Subprogram Dr. M.M.C. Collins, Division of Electrical Engineering, National  
Director: Research Council, Montreal Road, Ottawa, Ontario, K1A 0R8.  
613-993-2669.

Task: Energy Transportation and Transmission  
Program: Transmission and Distribution of Electricity  
Subprogram: Dielectric Insulation: Research at Non-Cryogenic Temperatures.

#### OBJECTIVE

To learn more of the characteristics of ageing of transmission cables at normal operating temperatures.

#### WORK

Accelerated ageing tests of power cable insulations subject to a wet or dry environment are continuing. A non-linearity in the effect of frequency on the acceleration has been confirmed for polymers in water. This effect will be studied further to elucidate the mechanism. The effect of water trees on impulse strength of insulation is being studied.

Long term and breakdown tests to evaluate an additive to prevent electrical trees in dry polymers have yielded conflicting results. Further tests to clarify the exact role of the additive are planned.

Tests to evaluate the life of materials using an electrode geometry more representative of service conditions have been organized. Test equipment to enable many specimens to be tested simultaneously is being designed. This will enable data to be obtained more rapidly.

Frequency accelerated aging of water immersed cables is greater at 400 Hz than 1 kHz. This unexpected result suggests that the ageing mechanism is more complete than originally thought. Cable manufacturers can use the less expensive 400 Hz test equipment to obtain adequate ageing acceleration. Tests to evaluate the additive have taken much longer than planned as specimens are tested one at a time. New equipment will speed up this testing.

78-79 Funds: \$171,000

79-80 Funds: \$175,000

Subprogram Director: Dr. M.M.C. Collins, Division of Electrical Engineering, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R8.  
613-993-2669.

1978-80

Task: Energy Transportation and Transmission  
Program: Transmission and Distribution of Electricity  
Subprogram: High Voltage Impulse Measurements and Standards.

## OBJECTIVE

To develop a fuller understanding of the problems involved in measuring high voltage impulses used in testing and to develop standards for those measurements. The work will result in improved reliability and performance of electrical transmission systems.

## WORK

Development of standards and related documents - there has been a continued input of the IEC on the standard for impulse voltage measurements and the application guide for that standard. Although the final part of the International Electrotechnical Commission Standard was published in 1977 and the American Standard in 1978, a number of problems remain which have to be clarified and more work must be done on the application of the Standards in industry.

Improvements of industrial measurement capabilities - the investigation of the suitability of standard commercial oscilloscopes for impulse voltage measurements is an important part of this project. a number of new oscilloscopes are being tested for their performance capabilities in the high voltage impulse environment. Whether or not they can be used with little or no added electrical shielding is an important factor in their suitability for this application. Further development of NRC's in-house measurement capabilities continues in order to provide a calibration facility for industrial measuring systems.

C.N. Tower (Toronto) lightning project - initial indications are that most of the current of a lightning stroke does not flow in the lightning conductors. Thus the work in 1979 measured the total current flowing in the tower by encompassing the tower, near the top, with a current measuring (Rogowski) coil. Improvements are also planned for the photographic system.

Ultra-fast impulses - a new project is designed to measure the electrical characteristics, both voltage and current, of ultra-fast impulses generated by power conditioning systems for lasers and related devices.

78-79 Funds: \$331,000

79-80 Funds: \$420,000

Subprogram Director: Dr. M.M.C. Collins, Division of Electrical Engineering, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R8.  
613-993-2669.

Task: Energy Transportation and Transmission  
Program: Transmission and Distribution of Electricity  
Subprogram: Measurement of Electric Power, Energy and Related Quantities.

## OBJECTIVE

To study the precise measurement of electrical quantities required for operational and standardization work in the electric power industry.

## WORK

Several projects are under way.

Power Bridge - this is a bridge for the calibration of power and energy meters at the national standards level. It has currently being used to improve the Canadian National Standard at power factors less than unity. An improved model of this bridge has been constructed and is undergoing tests. Extensions to measurements at 240 volts and for calibration of Var and Varhour meters are being developed.

Electrostatic charge reference - for calibration of partial discharge measuring equipment. No work has yet been done on this project.

AC impedance bridge - this bridge has been constructed and is being used for measuring components of other equipment.

Application of microprocessors to instrumentation - a highly accurate and stable digitally-derived 120 volt, 60 Hz source of modest cost has been developed and is undergoing test.

Reactive power definition - this is a wide-band, fast-acting, high accuracy wattmeter. The development of the functional circuitry is complete and sources of systematic error are being investigated. Construction of the interface devices is nearing completion. Negotiations with industry for its commercial development and exploitation are proceeding.

78-79 Funds: \$563,000

79-80 Funds: \$730,000

Subprogram Director: Dr. M.M.C. Collins, Division of Electrical Engineering, National Research Council, Montreal Road, Ottawa, Ontario, K1A 0R8.  
613-993-2669.



TASK 6

OVERALL COORDINATION

## Introduction to TASK 6: OVERALL COORDINATION

Overall coordination of the federal energy R&D program is provided by the Interdepartmental Panel on Energy R&D. The Panel, consisting of senior representatives from many federal departments, reports to the Minister of Energy, Mines and Resources.

The Panel's functions are to:

- review and assess the federal energy R&D program,
- ensure that this program is in harmony with energy policies,
- prepare and submit an annual program forecast for the program,
- advise Treasury Board on the allocation of resources and
- provide advice to the Minister of Energy, Mines and Resources on energy R&D matters.

The Office of Energy Research and Development (OERD) acts as secretariat to the Panel in providing the appropriate monitoring of the energy R&D program.

The Task Coordinator is:

Dr. P.J. Dyne  
Office of Energy Research and Development  
Energy, Mines and Resources  
580 Booth Street  
Ottawa, Ontario, K1A 0E4  
613-992-3738

This task is divided in two Programs:

6.1 Overall Coordination and Contingency Fund

6.2 Strategic Studies Support

The Program Convenor for both Programs is: Dr. P.J. Dyne.

GOVERNMENT OF CANADA

1978-80

Task: Overall Coordination  
Program: Overall Coordination and Contingency Fund  
Subprogram: --

## OBJECTIVE

To provide coordination and information focus for the federal energy R&D work and to disperse an energy R&D contingency fund.

## WORK

Funding under this Subprogram provides for the salaries and operating expenses of the staff of the Office of Energy R&D. OERD gives secretarial support to the Panel on Energy R&D, and is the coordination and information focus of the federal energy R&D activity. Its staff assists in establishing the relationship of R&D to energy policy objectives; and in seeking mechanisms for national applications of results. OERD staff are also responsible for maintaining, on computer, a data base of federal energy R&D; for evaluation and synthesis of reviews of federal energy R&D funding into submissions to the Panel, Cabinet and the Treasury Board; and for review and assessment of provincial, industrial and international energy R&D.

Also listed under this Subprogram are contingency funds the OERD controls for assignment during the fiscal year.

During 1978-79, OERD continued its policy of controlling existing reserves to particular programs, notably hydrogen and forest biomass. OERD also dispersed a fund of \$865K intended to provide flexibility and one-year bridge funding. Projects included a number of advance payments of IEA contributions; the rebuilding of the Magdallen Island VAWT; and the first hole of the Regina geothermal demonstration.

During 1979-80, controlled reserves for hydrogen and forest biomass were transferred to operating departments (NRC, DOE). OERD used its contingency fund to:

- collaborate with the NEA-IAEA effort to improve uranium exploration techniques;
- provide equipment for existing programs in laser fusion; spherical agglomeration; coal preparation, combustion, and conversion; tarsand upgrading; and wind resource measurement;
- complete research contracts in Agriculture Canada on energy conservation and production of energy from biomass on the farm;
- design future developmental programs for windmills and energy conservation in buildings;
- and to evaluate energy conservation potentials in communities and pulp mills.

During 1980-81, OERD will support new research programs in:

- automobile fuel economy;
- heat pump design and application;
- marine biomass resource evaluation;

(continued on next page)

Task: Overall Coordination  
Program: Overall Coordination and Contingency Fund  
Subprogram: --

(continued from previous page)

- energy conservation in new communities, the pulp and paper industry, and the food supply system beyond the farm gate;
- wood burning furnace safety;
- and the impacts of marine environments, particularly permafrost, on oil production facilities.

Contributions are also being made to Canadian involvement in IEA research agreements in hydrogen, fusion and wave energy.

78-79 Funds: \$1,665,000

79-80 Funds: \$1,356,000

Subprogram Director: Dr. P.J. Dyne, Director, Office of Energy Research and Development,  
Department of Energy, Mines and Resources, 580 Booth Street, Ottawa,  
Ontario, K1A 0E4. 613-992-3738.

GOVERNMENT OF CANADA

1978-80

Task: Overall Coordination  
Program: Strategic Studies Support  
Subprogram: --

## OBJECTIVE

To support studies that ensure the federal energy R&D activity is properly focussed in the context of medium and longer term energy policies and strategies.

## WORK

OERD supports linkages forged between energy R&D managers (and coordinators) and the Energy Policy Sector of EMR. These include the ongoing development of a fluid fuels strategy, policies for key renewable energy resources (biomass, wind and solar) and elements in the energy conservation and fossil fuel strategies.

The OERD budget of \$213K was devoted in 1978-79 to Canadian participation in the IEA-Brookhaven energy R&D futures study, and to a contract with the Institute for Research on Public Policy to review approaches to modelling Canadian energy futures and assessing their R&D implications. The Brookhaven-IEA study is continuing to provide Canada with an insight to the methodology currently being deployed by the IEA. In 1979-80 and 1980-81, the model is being run for Canadian federal and regional energy supply and demand scenarios.

In 1980-81, OERD will support a coordinated technical review of alternative fluid fuels supply and use strategies, for purposes of defining an appropriate national R&D effort and identifying suitable performers.

78-79 Funds: \$213,000

79-80 Funds: \$213,000

Subprogram Director: Dr. P.J. Dyne, Director, Office of Energy Research and Development,  
Department of Energy, Mines and Resources, 580 Booth Street, Ottawa,  
Ontario, K1A 0E4. 613-992-3738.



## APPENDICES

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ABBREVIATIONS

AC	Agriculture Canada
ACCORD	Analysis of CANDU Core Deformation
AECB	Atomic Energy Control Board
AECL	Atomic Energy of Canada Limited
AEMS	Aircraft Energy Monitoring System
AES	Atmospheric Environment Service (DFE)
AOSTRA	Alberta Oil Sands Technology Research Authority
API	American Petroleum Institute
ASTM	Amercan Society for Testing and Materials
CAISSE	Computer Activated Information System for Solar Energy
CANDU	Canada Deuterium and Uranium (the Canadian designed and built reactor)
CANMET	Canada Centre for Mineral and Energy Technology (EMR)
CASPPR	Canadian Arctic Shipping Pollution Prevention Regulations
CCA	Department of Consumer and Corporate Affairs
CEA	Canadian Electrical Association
CFS	Candian Forestry Service (EC)
CGA	Consumers Gas Association
CGRI	Canadian Gas Research Institute
CGSB	Canadian Government Specifications Board
CHF	Critical Heat Flux
CISTI	Canadian Institute for Scientific and Technical Information
CMHC	Canadian Mortgage and Housing Corporation
CREB	Conservation and Renewable Energy Branch (EMR)
CRNL	Chalk River Nuclear Laboratories (AECL)
CSA	Canadian Standards Association
DFE	Department of Fisheries and Environment (recently divided into Environment Canada and the Department of Fisheries and Oceans)
DND	Department of National Defence
DOE	Environment Canada
DPW	Public Works Department or Public Works Canada

DREE	Department of Regional Economic Expansion
DREO	Defence Research Establishment Ottawa (DND)
EAS	Economic Assessment Service (IEA)
EC	Environment Canada
EEC	European Economic Council
EMR	Department of Energy, Mines and Resources
ENFOR	Energy from the Forest (a Program of CFS)
ERL	Energy Research Laboratories (EMR)
FERA	Ferrous Industry Energy Research Association
GSC	Geological Survey of Canada (EMR)
HAWT	Horizontal Axis Wind Turbine
HUDAC	Housing and Urban Development Association of Canada
HVDC	High Voltage Direct Current
HWE	Hydrogen Water Exchange
IAEA	International Atomic Energy Agency
IEA	International Energy Agency of the OECD, Paris
IEC	International Electrotechnical Commission
IFC	Ice Forecasting Central
INA	Department of Indian and Northern Affairs
INFCE	International Nuclear Fuel Cycle Evaluation
IT&C	Department of Industry Trade and Commerce
LNG	Liquified Natural Gas
LOCA	Loss of Coolant Accident
LOCE	Loss of Emergency Coolant Accident
MSUA	Ministry of State For Urban Affairs (No longer exists)
NEA	Nuclear Energy Agency
NRC	National Research Council of Canada
OECD	Organization for Economic Co-operation and Development
OERD	Office of Energy Research and Development(EMR)
PASEM	Program of Assistance to Solar Equipment Manufacturers (DPW)
PUSH	Purchase and Use of Solar Heating (a Program of DPW)
PWC/CAD	Department of Public Works/Computer Aided Design
SAE	Society of Automotive Engineers
SLAR	Side-Looking Airborne Radar
STOL	Short Takeoff and Landing
TDSS	Transportation Development Strategic Studies (TC)
TC	Transport Canada
TEXTOR	Torus Experiment for Technology Oriented Research
TIS	Technical Information Service (IEA)

URP	Uranium Reconnaissance Program of the GSC
VAWT	Vertical Axis Wind Turbine
WNRE	Whiteshell Nuclear Reactor Establishment (AECL)
WRL	Western Research Laboratories (EMR)

GLOSSARY

ACCELERATOR: a device which accelerates electrically charged atomic or sub-atomic particles such as electrons, protons or ions to high energies.

AGGLOMERATION: the aggregation of small particles of a solid into larger clumps.

ANEROBIC DIGESTION: the use of microorganisms that can live only in the absence of oxygen to decompose organic materials into components that are more valuable or more easily disposed.

ARCTIC ISLANDS: refers to the Canadian Arctic islands.

BATHYMETRY: the measurement of the depths of oceans, seas or other large bodies of water.

BENEFICATION: cleaning and minimal processing to remove major impurities or otherwise improve properties.

BIOMASS: the whole range of materials produced by living organisms e.g., farm manure, agricultural plant waste, forest products.

"BLUE FLAME" TECHNOLOGY: refers to a burner design which creates the correct turbulence and other conditions in the air/fuel mixture to give a non-luminous (soot free) flame or blue flame. Developed in Canada.

CALORIMETER: any apparatus for measuring the quantity of heat generated in a body or emitted by it.

CANDU: The Canadian nuclear reactor system, which is moderated by heavy water (deuterium) and fuelled by natural uranium. The name is derived from CANada, Deuterium and Uranium.

CANDU-PHW: refers to the operational CANDU reactor moderated by pressurized heavy water (PHW).

CARBONIZATION: the conversion of an organic compound such as coal into char or coke by heat in the absence of air.

CARBON MONOXIDE, (CO): a colourless, odourless, tasteless poisonous gas usually formed in incomplete combustion of hydro-carbons.

CO-GENERATION: the use of thermal power stations to produce both heat and electricity for distribution.

COAL ASH: noncombustible matter in coal.

COAL LIQUEFACTION: the conversion of coal into liquid hydrocarbons and related compounds by hydrogenation at elevated temperatures and pressures.



COAL SLURRY: finely crushed coal mixed with sufficient water or other liquid to form a fluid.

COKE: the residue of coal left after destructive distillation; used as a fuel. Similar residue left by materials such as petroleum distilled to dryness.

COMBUSTION: the process of burning; rapid oxidation caused by the union of the oxygen of the air with a material.

"CONSERVER SOCIETY": the concept of a society that is against waste based on the perception of the world as finite and non-renewable resources as limited. It is a concept of a society that promotes economy of design of all systems, favours reuse and recycling, questions the ever-growing per capita demand for consumer goods etc.

CORONA: a discharge of electricity appearing as a bluish purple glow on the surface of and adjacent to a conductor when the voltage gradient exceeds a certain critical value; due to the ionization of the surrounding air by the high voltage.

CRACKING: the process of producing low molecular weight hydrocarbons from heavier hydrocarbons by heating with or without a catalyst. If the reaction is performed in the presence of excess hydrogen it is called hydrocracking.

CRYOGENICS: the study and production of very low temperatures and their associated phenomena.

DEUTERIUM: an isotope of hydrogen in which the nucleus contains a proton and a neutron. Deuterium oxide is commonly known as heavy water.

DIELECTRIC: a medium through which attraction or repulsion of electric charges may be sustained. Dielectrics are always insulators.

DISTRICT HEATING: the supply of heat, either in the form of steam or hot water, from a central source to a group of buildings.

DOSIMETER: a device that measures radiation dose such as a film badge or ionization chamber.

EHV (EXTRA HIGH VOLTAGE): a term applied to voltage levels of transmission lines which are higher than those in common use. At present, electric utilities generally consider EHV to be 345,000 volts or higher.

ELASTICITY: the responsiveness of a dependent variable to changes in a causal factor.

ELECTROCHEMICAL: chemical action employing a current of electricity to cause or sustain the action.

ELECTROLYTE: a substance that conducts electricity by the transfer of ions.

EXTENDOIL PROCESS: a thermal hydrocracking process developed in Canada for the production of synthetic crude from oil sands and heavy oils.

FIBRE OPTICS: the technique of transmitting light through long thin, flexible fibres of glass, plastic, or other transparent materials.

FISCAL YEAR: April 1 to March 31 of the following year. The fiscal year of the Canadian federal government.

FISSION: the splitting of certain heavy atomic nuclei into two atoms of much lower atomic weight and whose aggregate mass is less than that of the parent nucleus. The process is initiated by the capture of a neutron by the nucleus of the fissionable atom and is accompanied by the emission of one to three new neutrons. The lost mass appears as energy.

FLAT PLATE COLLECTOR: a non focussing device used to absorb solar radiation for the purpose of heating water or other liquid.

FLOCCULATION: the aggregation of fine particles in suspension in a liquid to form flocs.

FLUIDIZED BED: a reaction chamber in which finely divided solid reactants are suspended and maintained in a state of turbulence by a stream of gas or liquid from below.

FLY ASH: the fine solid particles of non combustible mineral residue carried from a bed of solid fuel by the gaseous products of combustion.

FLYWHEEL: a rotating element attached to the shaft of a machine for the maintenance of uniform angular velocity and revolutions per minute.

FRONTIER AREAS: Generally the undeveloped northern mainland, the offshore areas (east, west and Hudson Bay), the Arctic Islands (onshore and surrounding offshore) and the Mackenzie Delta-Beaufort Sea.

FUEL: any combustible material which gives off heat; also materials that can be fissioned in a chain reaction to produce heat.

FUEL CELL: an electro chemical device to convert chemical energy directly into electricity. A fuel cell behaves both like a battery and an engine.

FUEL CYCLE: the series of stages involved in supplying fuel for nuclear power reactors. It includes mining, refining, fuel fabrication, fuel use, spent fuel recovery, and refabrication into new fuel elements.

FUSION: the combination of two atomic nuclei to yield one larger nucleus whose mass is less than the aggregate mass of the original nuclei; the lost mass appears as energy.

GEOCHEMISTRY: the study of the distribution of the elements and of the atom species (isotopes) in the earth and the migration of the individual elements in the various parts of the earth and in minerals and rocks.

GEOTHERMAL ENERGY: energy from natural "hot spots" associated with hot, dry rock or large reservoirs of steam or hot water.

H<sub>2</sub>O: represents a molecule of water in which one hydrogen atom has been replaced by deuterium. Deuterium oxide or heavy water

HEAT PUMP: a device which transfers heat from a colder to hotter reservoir by the expenditure of mechanical or electrical energy when the primary purpose is heating the hot reservoir. A heat pump is essentially a reversed refrigeration process.

HEAVY OIL: oil of high specific gravity and high viscosity, cannot be produced by drilling as in normal oil wells. It has to be mined. Large deposits found in western Canada.

HEAVY WATER: deuterium oxide, see "HDO".

HIGH VOLTAGE IMPULSE: very short surge of high voltage produced by impulse generator.

HVAC: heating, ventilating and air conditioning.

HYDRATE: a compound or complex ion formed by the union of water with some other substance and represented as actually containing water.

HYDRIDE: a binary compound formed by hydrogen and another usually more electropositive element or group.

HYDROCARBON: a compound that contains only hydrogen and carbon.

HYDROGEN-AMINE PROCESS: also known as amine-hydrogen process. A process for heavy water production utilizing exchange of deuterium between hydrogen gas and amino methane liquid which is catalysed by potassium methylamide dissolved in the amine liquid.

HYDROGENATION: form of reduction at high pressure in which gaseous hydrogen reacts with a substance in the presence of a catalyst.

INERTIAL CONFINEMENT: one of the two approaches to demonstrate controlled thermonuclear fusion; the very rapid heating of a small solid pellet within the expansion time of the plasma by use of laser or accelerators; it is essential that the plasma be isolated from the walls of the reactor to avoid contamination and subsequent quenching of the fusion reaction.

IN SITU: Literally means "in place" and refers to recovery techniques applicable in heavy oil, oil sands and coal deposits without removing the complete material from location.

ISOMERISM: the phenomenon whereby certain chemical compounds have structures that are different although the compounds possess the same elemental composition.

ISOTOPE: any of two or more species of atoms with the same atomic number but with different atomic masses, i.e. the same number of protons but different numbers of neutrons.

J(JOULE): a unit of energy or work which is equivalent to one watt per second.

LEAN: refers to a fuel mixture being low in combustible component.

LIGNITE: a brownish black coal in which the alteration of vegetal matter has proceeded further than in peat but not as far as in subbituminous coal.

LIQUEFIED NATURAL GAS (LNG): natural gas cooled to about - 160°C so that it forms a liquid, reducing the volume nearly 600 fold.

LOAD FACTOR: the ratio of the average load in kilowatts supplied during a designated period to the peak or maximum load in kilowatts occurring in that period.

LURGI PROCESS: a type of coal gasifier (steam-coal-oxygen) which employs a bed of crushed coals travelling down through the gasifier with steam and oxygen travelling up through the bed. The gasifier operates at pressures of up to 30 atmospheres and produces a hydrogen rich gas.

MAGNETO-TELLURIC METHOD: utilization of the natural variation in the earth's magnetic field to measure electrical resistivity to indicate temperature in the earth's crust.

METALLURGICAL COAL: coal with strong or moderately strong coking properties that contains no more than 0.8 % ash and 1.25 % sulfur as mined or after conventional cleaning.

METHANE ( $\text{CH}_4$ ): carbureted hydrogen or marsh gas or fire damp, formed by the decomposition of organic matter. The most common gas found in coal mines and the major constituent of natural gas. It is a tasteless, colourless, odourless non-poisonous gas which forms an explosive mixture with air.

METHANOGENESIS: the biosynthesis of methane; common in certain bacteria.

METHANOL: a light volatile flammable poisonous liquid alcohol ( $\text{CH}_3\text{OH}$ ) formed synthetically or from the destructive distillation of wood.

MODERATOR: a material used in some nuclear reactors to reduce the energy of neutrons.

NATURAL GAS: naturally occurring mixtures of hydrocarbon gases and vapours.

NATURAL URANIUM: uranium as found in nature, containing 0.7 % of uranium-235 99.3 % of uranium-238 and traces of uranium-234.

NEUTRON: an uncharged elementary particle with a mass slightly larger than that of a proton. It is present in all atomic nuclei except hydrogen.

NRU REACTOR: experimental nuclear reactor at Chalk River, Ontario.

NUCLEAR REACTOR: a device in which a fission chain reaction can be initiated, maintained and controlled.

OIL SANDS: vast deposits of sands and clay which are heavily impregnated with oil. The largest known deposits in the world are in western Canada.

OXIDES OF NITROGEN ( $\text{NO}_x$ ): usually formed in combustion processes; they are nitrous oxide, nitrogen dioxide and nitric oxide.

PEAT: starting material in coal genesis. Formed in marshes and swamps from partly decomposed remains of marsh vegetation. Peat is yellowish brown to brownish black, is generally fibrous in consistency and has a high moisture content.

PERMAFROST: perennially frozen subsoil found in Arctic and sub-Arctic regions, in both terrestrial and marine environments.

PHOTOCHEMISTRY: a branch of chemistry dealing with the effects of radiant energy in producing chemical change.

PLASMA: an electrically neutral, partially ionized gas in which the motion of the constituent particles is dominated by electromagnetic inter-actions.

PLUTONIUM: an element that is very rare in nature. It is usually obtained by exposure of uranium-238 to neutrons in a reactor.

POLYMER: substance made of giant molecules formed by the union of simple molecules (monomers).

PROTOTYPE: the stage following the basic idea for a new machine. It is an experimental model which assists the inventor and manufacturer in solving difficult details.

PYROLYSIS: the transformation of a substance into another compound or compounds by the application of heat alone.

RADIOACTIVITY: the spontaneous disintegration of the nucleus of an atom with the emission of corpuscular or electromagnetic radiation.

RADIOMETRIC PROSPECTING: location of minerals using a geiger counter or scintillometer that measures radioactivity.

RADON: a radioactive gaseous element formed by the disintegration of uranium.

RANK: a classification of coals according to % of fixed carbon and heat content.

SPHERICAL AGGLOMERATION PROCESS: a Canadian developed process using surfactants in which bitumen separates from oil sands into globules.

SEISMIC EXPLORATION: a method of prospecting for oil and gas by sending shock waves into the earth.

SEMI-CONDUCTOR: a solid crystalline material whose electrical conductivity is intermediate between that of a metal and an insulator.

SF<sub>6</sub>: sulfur hexafluoride, a gas used for insulation in electricity transmission and distribution.

SLAR: Side-looking airborne radar - a radar which can penetrate cloud cover and vegetation thus enabling "photography" from which maps can be made.



SLURRY: a free flowing pumpable suspension of fine solid material in liquid.

SPALLATION PROCESS: bombardment of heavy elements by energetic nucleons, such as protons, to fragment them and produce neutrons.

STEAM TABLES: tabulations giving data relating to steam saturated at various temperatures and including pressure, specific volume, density, heat of vaporization, specific enthalpy and specific entropy.

SYNTHETIC NATURAL GAS (SNG): a manufactured gaseous fuel usually produced from naphtha or coal. It contains 95 to 98 % methane.

TAR SANDS: see Oil Sands

THERMODYNAMICS: study of the transformations of energy into other manifested forms and of their practical applications.

THORIUM: a radioactive element of atomic number 90; naturally occurring thorium has one main isotope, thorium-232. The absorption of a neutron can result in the creation of uranium-233.

TIDAL ENERGY: utilization of the tides as a source of energy based upon schemes which harness on potential energy of the tides, the kinetic energy of the tidal currents or both.

TREE: a set of connected circuit branches that includes no meshes; responds uniquely to each of the possible combinations of a number of simultaneous inputs.

TRIBOLOGY: the study of friction and wear.

TURBINE: a rotary engine turned by the impulse from a current of fluid under pressure.

URANIUM: a radioactive element with the atomic number 92 and, as found in natural ores, an average atomic weight of 238. The principal isotopes are uranium-239 (99.3 %) and uranium-235 (0.7 %).

URBAN FORM: community design and lay-out.

VACUUM DISTILLATION: distillation under reduced pressure. The boiling temperature is thereby reduced sufficiently to prevent cracking of the material being distilled.

VERTICAL AXIS WINDMILL: refers to the radical new vertical axis windmill developed by the National Research Council.

WAVELENGTH: the distance between similar points on successive waves.

WIND GENERATORS: devices that extract energy from the wind to generate electricity directly.

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15. "TDC Project Directory", Report TP 1936 Transport Canada Research and Development Centre, Montreal. 1979 Edition.
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18. "Annual Report on Energy Research, Development and Demonstration Activities of the IEA 1978-1979" Organization for Economic Co-operation and Development.
19. "Renewable Energy Research and Development in Canada" NRC Report No. 17978, M.S. Chappell, Energy Project Office, NRC, December 1979.
20. "Research Agreements Program Progress Summary 1980" EMR Ottawa January 1980.
21. "Survey of Current Electric Utility Research in Canada", 1979-80 Edition, Canadian Electrical Association.

INTERNATIONAL ENERGY AGENCY R&D

Below is a list of IEA Implementing Agreements that have been established by IEA Working Parties in various fields. Projects in which Canada is involved are marked with an asterisk(\*).

## IMPLEMENTING AGREEMENT ON:

## \* Solar Heating &amp; Cooling:

- ANNEX 1 - Performance
- 2 - Development of Components for Heating and Cooling.
- \* 3 - Performance Testing of Solar Collectors.
- \* 4 - Development of an Insolation Handbook and Instrumental Package.
- \* 5 - Use of Meteorological Information for Solar Energy Application.
- \* 7 - Central Solar Heating Plants with Seasonal Storage - Feasibility Study and Design.

## Small Solar Power Project

## Ocean Energy Systems

- \*ANNEX 1 - Wave Power Air Turbine Generating Systems

## \* Forestry Energy

## \* Biomass Technical Information Service

## R&amp;D on Wind Energy Conversion Systems

- \* 1 - Environmental Meteorological Aspects of Wind Energy Systems.
- \* 2 - Evaluation of Models for Wind Energy Siting.
- 3 - Integration of Wind Power into National Electricity Supply Systems.
- 4 - Investigation of Rotor Stressing and Smoothness of Operation of large-Scale WECS.

## Large-Scale Wind Energy Conversion Systems

## Geothermal Equipment

ANNEX 1 - Test and Demonstration of a 1 MW Well-Head Generator

## R&D on Man-Made Geothermal Energy Systems

ANNEX 1 - R&D on Man-Made Geothermal Energy Systems

## \* Building and Community Systems

- \*ANNEX 1 - Establishment of Methodologies for  
Load/Energy Determination of Buildings
- 2 - Energy Systems and Design of Communities
- 3 - Evaluation of Energy Conservation Measures for Heating  
of Residential Buildings
- \* 4 - Glasgow Commercial Building Monitoring Project
- \* 5 - Air Infiltration Centre
- 6 - Energy Systems and Design of Communities (Annes 2  
continued - title tentative)
- \* 7 - Air Infiltration in Residential Buildings
- 8 - Local Energy Planning

## \* Energy Cascading

\*ANNEX 1 - Common Study for Energy Cascading: Establishing  
Priorities for Cooperative Research and Development

## Building Complexes

- ANNEX 1 - Wiehl Demonstration Project
- 2 - Esslingen Demonstration Project

## Heat Pump Systems

ANNEX 1 - Heat Pump Systems with Thermal Storage

## \* Advanced Heat Pumps

\*Annex 1 - Common Study of Advanced Heat Pump Systems

## Energy Storage

- ANNEX 1 - Large-Scale Thermal Storage Systems
- 2 - Lake Storage Demonstration in Mannheim

## Heat Transfer and Heat Exchangers

ANNEX 1 - Extended Surface Heat Transfer



- 2 - The Optimal Design of Heat Exchanger Networks
- 3 - Heat Exchanger Tube Vibration

Combustion

ANNEX 1 - Energy Conservation in Combustion

Cement Manufacture

ANNEX 1 - Energy Conservation in Cement Manufacture

\* Iron and Steel

\* Pulp and Paper

Agriculture

\* Urban Waste

\*ANNEX - Common Study on Urban Waste Utilization

Food Processing

High Temperature Materials for Automotive Propulsion Systems

ANNEX 1 - Investigation of Ceramic Material Properties

2 - Definition of Experimental Material Characterization  
Methods

\* For the Establishment of a Project on Control of Nitrogen Oxides  
Emissions During Coal Combustion

\* Mining Technology Clearing House

\* Cooperation in the Field of Atmospheric Fluidized-Bed Combustion in  
Industrial or District Heating Boiler Power Generation

\* Cooperation in the Field of Coal/Oil Mixtures in Utility Steam  
Generators

\* Technical Information Service

R&D Programme on the Production of Hydrogen from Water

Plasma Wall Interaction in TEXTOR

FEDERAL-PROVINCIAL AGREEMENT ON DEMONSTRATION  
OF CONSERVATION AND RENEWABLE TECHNOLOGIES

APPROVED PROJECTS  
AS OF SEPTEMBER 1980

BRITISH COLUMBIA

1. Geothermal Energy Meager Creek (300)\*
  - (4.5)\*\* Exploration of the commercial prospects of a geothermal power plant in the Meager Creek area with B.C. Hydro.
2. Solar Domestic Hot Water (130)
  - (4.2) Demonstration of one hundred solar domestic hot water systems placed in various locations in British Columbia
3. Fluidized Bed Combustion Unit (3.5)
  - (1.5) A comparative technical and economic evaluation of commercially available fluidized bed boilers and advanced prototype boilers to utilize wood-wastes, municipal garbage, coal and hog fuel. Phase I of a three phase project.
4. Wet Cell Burner for Lime Kiln (0)
  - (4.3) Demonstration of the use of hog fuel to fire a lime kiln using the Lamb-Cargate Wet Cell Burner.
5. Congeneration Using Refuse Derived Fuel (21.4)
  - (1.5) A feasibility study of using refuse derived for fuel for the congeneration of electricity and steam in metro Victoria. Phase I of a multi-phase project.
6. Energy Efficient Small Commercial Buildings (10)
  - (1.1) Demonstration of an energy efficient small commercial building utilizing conservation measures, passive solar and efficient lighting.
7. Low Energy Residential Housing (68)
  - (1.1) Assessment of the merits of passive solar versus super-insulation at statistically minimum backup energy demand by monitoring six single family housing units.
8. Service Industry Solar Hot Water System (19.2)
  - (4.2) Demonstration of a solar hot water system for the provision of low temperature process hot water.

\* 1980-81 Federal Funds \$000

\*\* R&D Program Number of the technology being demonstrated.

9. Energy System for School on Lasqueti Island (0)

- (1.1) A design and detailed implementation plan of an integrated multi-source energy system considering conservation measures and renewable energy sources.

10. Grandview Housing Co-op DHW Preheat (17.5)

- (4.2) Domestic hot water solar preheater installation for a 19 suite apartment building.

11. Conservation and Alternate Energy Measures for Recreation Centre (5)

- (1.4/  
1.11) Evaluation of the technical and economic feasibility of recovering waste heat from HVAC system, hot water, of utilizing solar energy and of utilizing heat pumps to extract heat from a creek and sewer line.

12. Vancouver Energy Information Center (52.6)

- (1.1) Retrofitting of a small office building and operating it as an energy information center to promote public awareness of energy conservation and renewable energy.

13. Small Hydro (15KW) for Sport Fishing Resort (6.9)

- (4.1) Demonstration of a 15KW small hydro facility replacing diesel generators in an all year round sport fishing resort.

NORTH WEST TERRITORIES

1. Fort Providence Wood Gasification (195.7)

- (4.3) Demonstration of a wood gasification system for power generation and district heating.

SASKATCHEWAN

1. Saskatoon Low Energy Homes (183)

- (1.1) Demonstration of low energy homes for the mass housing market (Part of Canada's contribution to the international Energy Agency).

2. Conservahome Project (163)

- (1.1) Demonstration of a wide range of retrofit measures in six houses of various types and ages.

3. Regina Geothermal Project (76)

- (4.5) Utilization of heat stored in hot water porous formations beneath the Prairies for space heating or other direct heat applications.

4. Hudson Bay Gasifier (55)

- (4.3) Demonstration of the commercial viability of the fixed bed mode Saskatchewan Power Corporation wood gasifier at Hudson Bay and to modify the plant to a fluidized bed mode in an effort to improve output and economics.

5. Farmstead 2000 (0)

- (1.3) Demonstration of state-of-the-art energy conservation techniques, biomass utilization, renewable energy production and innovative soil management practices with three commercial demonstration farms and fifty operating commercial farms.

6. Greenhouse Heating with Gas Turbine Exhaust (0)

- (1.3) Utilization of gas turbine exhaust gases for greenhouse heating and carbon dioxide enrichment in a demonstration greenhouse complex at a compression station.

8. Energy Audit of Agricultural Buildings (77.5)

- (1.3) On site energy analyses of agricultural buildings (similar to the Energy Bus) and provision of information on reduction of energy consumption.

MANITOBA

1. Infiltration Device (3.3)

- (1.1) Construction and testing of a pressure testing device for determining the air tightness of buildings.

2. Energy Efficient Home (5.4)

- (1.1) Construction, monitoring and documentation of an energy efficient home.

3. Winkler Swimming Pool Solar System (0.7)

- (4.2) Construction of a basic solar heating system for a public swimming pool in a small community.

4. Thermostatically Controlled Engine Block Heater (60)

- (1.2) Development and demonstration of a thermostatically controlled engine block heater based on the use a PTC thermistor.

5. Air Infiltration Testing of 100 Newly Sealed Homes (16.7)

- (1.1) Air infiltration testing and analysis of 100 homes which have been sealed against air infiltration. Testing will be done before and after sealing.

3. Toronto Sludge Incinerator (5)
  - (1.5) Feasibility study of installing energy recovery facilities to recover heat from the off gases of the sewage sludge from Toronto Ashbridges Bay sewage plant.
4. North Bay Energy From Waste (12.5)
  - (1.5) Feasibility study of incineration plant with energy recovery from wood residues, municipal garbage and sewage sludge.
5. Niagara Energy From Waste (50)
  - (1.5) Feasibility study of incineration with cogeneration from garbage in Thorold, Ontario.
6. St. Catherines Energy From Waste (12)
  - (1.5) Feasibility Study of a small scale energy from waste facility to convert municipal garbage into energy for industrial use.
7. St. Lawrence District Heating (25)
  - (1.4) Feasibility study and engineering design of a district heating system based on natural gas for the St. Lawrence Neighbourhood in Toronto.
8. Residential Passive Solar Design and Construction (100)
  - (4.2) Development, optimization and construction of passive solar heating designs for standard residential construction.
9. Le Breton Flats District Heating (412.5)
  - (1.4) Installation and monitoring of a small scale district heating system based on natural gas for the provision of space heating and domestic hot water to about 240 residential units out of a total project development of 425 units.
10. Ottawa - Carleton Energy From Waste (?)
  - (1.4) Feasibility study and engineering design of a cogeneration system using municipal waste, wood and coal.
11. Ecology House Retrofit (27.5)
  - (1.1) Demonstration of energy conservation using the retrofitted Ecology House as an information and education centre for the general public.
12. Residential Retrofit Film (31.2)
  - (1.1) Production of a film on residential retrofit with the Ecology House as its foundation which will present simple economically feasible alternatives for energy conservation.



## NEW BRUNSWICK

1. Grand Lake Aquaculture (106.6)
  - (1.4) Demonstration of the use of waste heat from a thermal power plant for a hatchery and early rearing facilities for salmon and trout.
2. The Conservation House (98.4)
  - (1.1) Demonstration of the potential for incorporating the latest renewable energy and energy conservation technologies in the existing housing stock by retrofitting an old house then using it as an information centre.
3. Passive Solar Addition to Existing Home (6.4)
  - (4.2) Small scale demonstration of the economic and aesthetic feasibility of retrofit passive solar to existing homes.
4. Commuter Transport Pooling (9.6)
  - (1.2) Establishment of energy efficient commuter pools using appropriate vehicles in lieu of travelling to work alone in a private automobile by subsidization of 3 year commuter demo projects for the first two years.

## NEWFOUNDLAND

2. Wind Driven Generator for Microwave Station (43.2)
  - (4.4) Demonstration of the use of a vertical axis wind turbine in conjunction with a diesel generator operating cyclically, to charge a bank of batteries which supply power to a microwave station.
3. Fuel Peat For Hog Fuel Boiler (25)
  - (4.3) Demonstration of peat harvesting, transportation and burning in an existing hog fuel boiler in a pulp and paper plant.
4. Wood Waste Fuel For Hospital Steam (270)
  - (4.3) Demonstration of collection, transportation and burning in a wood-fired boiler of sawdust and shavings to supply steam requirements of a hospital.
5. Aquarena Retrofit Energy System (162)
  - (1.4) Demonstration of a modified energy system for a large swimming facility utilizing heat recovery from pool air to reheat the pool building, heat the pool and preheat domestic water.

6. Pippy Park Solar and Wood Stoves (2.5)

- (4.2/ Small scale demonstration of use of passive solar (trombe walls)
- 4.3) and wood stoves to heat scout/guide campsite.

7. Low Energy Housing (100)

- (1.1) Construction of an energy efficient single family home with high insulation levels, appropriate heating system, heat recovery from exhaust air and solar/heat pump/gray water heat exchange for preheating service water.



